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Assessment of Eastern Georges Bank Haddock for 2007

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2006 was 12,642 mt under a combined Canada/USA quota of 22,000 mt. The 2006 Canadian catch decreased from 14,536 in 2005 to 12,051 mt while the USA catch increased slightly from 569 mt in 2005 to 591 mt. Estimated discards from the Canadian scallop fishery were 67 mt and were 146 mt from the USA groundfish fishery. EGB haddock catches fluctuated about 5,000 mt during 1985-1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,200 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass (ages 3+) has steadily increased from near an historical low of 8,500 mt in 1993 to 69,500 mt in 2003. Adult biomass subsequently decreased to about 46,900 mt at the beginning of 2005 but increased to 145,300 mt in 2007, higher than the 1931-1955 maximum of about 90,000 mt. The exceptional 2003 year class, estimated at 321.7 million age-1 fish, is the largest observed in the assessment time series (1931-1955 and 1969-2005). The 2001, 2002 and 2004 year classes, at less than 8 million, are below the recent 10 year average of 18 million fish while the 2005 year class, at 30.5 million, is above the average. Initial estimates of the 2006 year class suggest that it is about the size of the 2004 year class. Fishing mortality (ages 4+) was below F_{ref} = 0.26 during 1995 to 2004. The failure of the 2003 year class to recruit as expected to the 2005 and 2006 fishery resulted in fishing mortality in 2005 and 2006 exceeding F_{ref} (F_{2006}=0.36). With expanded age structure, broad spatial distribution and generally higher recruit per spawner ratio, resource productivity is high, negatively impacted only by recent reductions in fish weight at age.

Assuming a 2007 catch equal to the 19,000 mt total quota, a combined Canada/USA catch of 26,700 mt in 2008 would result in a neutral risk (50%) that the fishing mortality rate in 2008 will exceed F_{ref} = 0.26. A catch of 23,000 mt would result in a low risk (25%) that the fishing mortality rate in 2008 will exceed F_{ref}. However, there is high uncertainty in the partial recruitment estimated for the 2003 year class. Using the observed range of partial recruitment at fishery weight during 1995 to 2006, the 2008 projected catch could vary from 17,000 mt to 31,000 mt.

The failure of the 2003 year class to contribute as expected to the fishery resulted in more of the 2000 and older year classes being caught in 2006 than had been projected from the 2005 assessment. Slow growth of the 2003 cohort will continue to impact the fishery. If the total allowable catch in 2007 is caught, fishing mortality will, again, be higher than F_{ref} on the fully recruited ages (F_{5+}=0.33) because the 2007 age 4 fishery partial recruitment is now estimated at 0.2 compared to 0.3 from the 2006 assessment.

RÉSUMÉ

Les prises totales d'aiglefin dans l'est du banc Georges en 2006 se sont chiffrées à 12 642 tm, par rapport à un TAC combiné Canada-É. U. de 22 000 tm. Les prises canadiennes ont diminué, passant de 14 536 tm en 2005 à 12 051 tm en 2006, tandis que celles des États Unis ont légèrement augmenté, passant de 569 tm en 2005 à 591 tm en 2006. Les rejets en provenance de la pêche du pétoncle au Canada et de la pêche du poisson de fond aux États-Unis ont été estimés à 67 tm et 146 tm, respectivement. Les fluctuations des prises d'aiglefin dans l'est du banc Georges ont été d'environ 5 000 tm au cours de la période 1985 1990. Des mesures de gestion strictes ont fait baisser les prises combinées du Canada et des États-Unis, qui, après avoir dépassé 6 500 tm en 1991, sont tombées à un seuil d'environ 2 200 tm en 1995. Ces prises se sont ensuite situées en moyenne à 3 600 tm de 1996 à 1999 et elles ont augmenté depuis.

La biomasse de la population d'adultes (âges 3+) a constamment augmenté, passant du seuil quasi historique de 8 500 tm qu'elle avait connu en 1993 à 69 500 tm en 2003. Elle est tombée à 46 900 tm au début de 2005, mais elle a ensuite augmenté à 145 300 tm en 2007, dépassant d'environ 90 000 tm la biomasse maximale des années 1931-1955. L'exceptionnelle classe d'âge de 2003, estimée à 321,7 millions de poissons d'âge-1, est la plus grande classe d'âge observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2005). En revanche, les classes d'âge de 2001, 2002 et 2004, chiffrées à moins de 8 millions de poissons, se situent sous la moyenne des 10 dernières années, soit 18 millions de poissons, tandis que la classe d'âge de 2005, avec un effectif de 30,5 millions de poissons, est supérieure à la moyenne. Les premières estimations de la classe d'âge de 2006 portent à croire que son effectif équivaut à peu près à celui de la classe d'âge de 2004. La mortalité par pêche (parmi les âges 4+) a été inférieure à $F_{réf.}$ = 0,26 de 1995 à 2004. Le recrutement attendu de la classe d'âge de 2003 à la pêche de 2005 et de 2006 ne s'étant pas produit, la mortalité par pêche de 2005 et de 2006 a été supérieure à $F_{réf.}$ (F_{2006} = 0,36). En raison de l'élargissement de la structure d'âges, de la vaste distribution spatiale et du taux généralement plus haut de recrutement par reproducteur, la productivité de la ressource est haute, n'ayant subi comme effet négatif que les réductions récentes du poids du poisson selon l'âge.

En se fondant sur des prises hypothétiques en 2007 égales au quota de 19 000 tm, des prises combinées Canada/États-Unis de 26 700 tm en 2008 se traduiraient par un risque neutre (50 %) que la mortalité par pêche dépasse $F_{réf.}$ = 0,26 en 2008. Des prises de 23 000 tm aboutiraient à un faible risque (25 %) que la mortalité par pêche en 2008 dépasse $F_{réf.}$ Toutefois, le recrutement partiel estimé pour la classe d'âge de 2003 est très incertain. D'après la fourchette des valeurs observées dans le recrutement partiel selon le poids de 1995 à 2006, les prises projetées pour 2008 pourraient varier entre 17 000 tm et 31 000 tm.

Étant donné que la classe d'âge de 2003 n'a pas contribué autant que prévu à la pêche, la quantité de poissons de la classe d'âge de 2000 et des plus vieilles classes d'âge qui a été capturée en 2006 a été supérieure à ce que prévoyait l'évaluation de 2005. La lente croissance de la cohorte de 2003 continuera de se répercuter sur la pêche. Si le total autorisé des captures est capturé en 2007, la mortalité par pêche sera de nouveau supérieure à $F_{réf.}$ parmi les âges pleinement recrutés (F_{5+} = 0,33), parce que le recrutement partiel à la pêche des poissons d'âge 4 en 2007 est maintenant estimé à 0,2, alors que l'évaluation de 2006 le chiffrait à 0,3.

Introduction

For the purpose of developing a sharing proposal and consistent management by Canada and the USA, agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (EGB) (DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute and Brodziak (2006) to Canadian and USA fisheries information updated to 2006. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2007, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2007, and fall, updated to 2006, were incorporated.

Fishery

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982). Catches from EGB during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s, ranging up to about 23,000 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, fluctuated between about 3,000 mt and 4,000 mt until 1999 and increased to 15,112 mt in 2005 (Table 1, Figure 3). In 2006, the Canadian catch was 12,051 mt and the USA catch was 591 mt under quotas of 14,520 mt for Canada and 7,480 mt for the USA for a total combined catch of 12,642 mt (combined quota was 22,000 mt). The landings for 2005 were updated from what was reported in the previous assessment but differences were minor.

Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Canadian catches since 1995 were below the quota due to closure of some fleet sectors when the cod quotas were reached, except for the year 2000 when the catch of 5,402 mt was slightly above the Canadian quota of 5,400 mt. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings in 2006 were monitored at dockside and at-sea observers monitored 31% by weight of the haddock landed in 2006. Discarding and misreporting of haddock by the groundfish fishery have been negligible since 1992.

Since 1994, the Canadian fishery for groundfish was usually not permitted from 1 January to 30 May. In 2005 and 2006, increasing haddock abundance led to an exploratory Canadian groundfish fishery. So as not to adversely affect the rebuilding of

cod on EGB, the exploratory winter fishery was closed (February 6 in 2006) when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning stages.

In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. Some elements of the management measures used on EGB are described in Table 2. Smaller vessels are allowed to fish the quota which has been allocated to the larger vessels under the Temporary Vessel Replacement Program (TVRP) and increasing amounts of this quota have been taken by the TVRP boats in recent years. In 2006, 95% of the catch was taken by tonnage class 1, 2 and 3 (less than 150 tons) vessels (corresponding roughly to vessels less than 65 ft in overall length). Otter trawls took 84% of the haddock and longliners took 16% (Table 3). The highest monthly catches in 2006 occurred during August followed by July and September (22%, 20% and 18%, respectively) (Table 4, Figure 4). The winter fishery accounted for 13% of the landings.

Canadian landings until 1995 include those catches reported by the scallop fishery, but, since 1996, this fishery has been prohibited from landing haddock and this species was then discarded. Landings of haddock by the scallop fleet have been low (Table 3) with a maximum of 38 mt reported in 1987. Discards of haddock ranged between 29 and 186 mt since 1969 and were estimated at 67 mt in 2006 (Table 1) (Gavaris et al 2007). Details of discard calculations for the EGB scallop fishery for 1960 to 2005 can be found in Van Eeckhaute et al, 2005 and for 2006 in Van Eeckhaute and Gavaris, 2006.

Management measures for the USA fishery since 1994 have been effort based but, in 2004, quota management was introduced to regulate the USA groundfish fishery (Table 2). USA landings of EGB haddock in 2006 were derived from mandatory fishing vessel logbooks and dealer reports using the same procedures as for 1994-2005 (Wigley et al 1998). To estimate otter trawl discards, the discard to kept ratios from observed trips were used. Quarters 1 and 2 landings were combined and the quarter 2 discard to kept ratio was applied to estimate the combined quarters 1 and 2 discards. The quarter 3 ratio was applied to the quarter 3 discards. There were no landings, therefore no discards, reported for quarter 4.

USA catches, in 2006, of EGB haddock increased slightly from the previous year (569 mt) and were 591 mt under a catch quota of 7,480 mt (Table 1). As in 2005, the catch was constrained by the low cod quota with the fishery closing during the first half of the season when the cod quota was close to being reached. Quarterly USA landings in 2006 were: 47 mt (11%), 393 mt (88%), 5 mt (1%) and 0 mt (0%) for calendar quarters 1 to 4 respectively (Table 5).

USA discards from the otter trawl fishery increased from 57 mt in 2005 to 146 mt in 2006. Discards from this fleet had been relatively low in recent years due to high trip limits and larger trawl mesh size but, in 2006, 25% (by weight) of the haddock catch was discarded, an increase from 2004 and 2005 when discards accounted for 8% and 10%, respectively, of the USA catch. The discards from the scallop fleet were not available but have been insignificant in the past.

Otter trawl gear accounted for the majority of the USA landings (414 mt). The contribution by other gear (31 mt) was 7%, higher than previous years since 1994, except for 2005, which was slightly higher at 9% (Table 6).

Size and Age Composition

The size and age composition of haddock in the 2006 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears and seasons (quarters) (Table 7). For trips that were sampled by both at-sea observers and port samples, the length frequencies were combined to ensure that samples were used in a consistent manner. The size composition of haddock discards in the 2006 Canadian scallop fishery was characterized by quarter using length samples obtained from 11 observed scallop trips (Table 7). The 2006 DFO survey ages were applied to the first quarter length composition and fishery age samples for quarters 2 to 4 were applied to the corresponding length compositions for both the groundfish fishery and discards. Van Eeckhaute and Brodziak (2006) describe the methods used to characterize size and age composition in previous years.

The size composition of landings in the Canadian fisheries peaked at 52 to 55 cm for otter trawlers and longliners (Figure 5). The proportion of small haddock increased as the fishery progressed through 2006 (Figure 6). Gill-netters caught few haddock. The percentage of haddock below 43 cm increased from 1% in 2005 to 10% in 2006. The scallop dredge discards peaked at 40.5 cm.

USA landings of EGB haddock are divided into large and scrod market categories for sale purposes. Landings of large haddock totaled 132 mt and scrod haddock totaled 313 mt in 2006 (Table 8). Length samplings for USA EGB landings in 2006 were limited to quarters 2 and 3 with only 104 large fish and no scrod measured for quarter 3. Age sampling was similarly distributed with a total of 640 ages. Lengths were augmented from unit areas 522 (5Zh) and 525 (5Zn) for quarter 1 large and scrod and for quarter 2 scrod. Observer coverage decreased from a total of 44% (226 mt) of USA haddock landings by weight from EGB in 2005 to 1.6% (7 mt) in 2006 during a total of 54 trips.

Samples of discards collected by at-sea observers were used to characterize the catch at length of the USA discards. Discard samples were available only for the otter trawl fleet. Scallop fleet discards were not available in time to include here but haddock discards from this fleet were insignificant. For the otter trawl fleet, only one fish measurement was taken in quarter 1 so quarters 1 and 2 were combined for the discards at age analysis. Quarter 3 had sufficient samples to obtain a length composition.

USA landings peaked at 54.5 cm and discards peaked around 30.5 to 36.5 cm with another much smaller mode at 52 cm (Figure 7). The reason for discarding of large haddock could not be explained. The high number of small discards was attributed to the use of diamond mesh and the use of chaffing gear.

Due to the low level of sampling and with the majority of the landings in quarter 2, an annual age-length key was applied to the USA landings and the resultant landings at age were assigned to quarter 2, where most of the landings occurred. For the otter trawl discards at age, quarter 2 and 3 age data were borrowed from USA port samples and

Canadian port and observer samples and from the NEFSC spring survey to cover smaller fish in quarter 2 and from the NEFSC autumn survey to cover smaller fish in quarter 3. The quarter 2 age-length key was applied to the combined discards for quarters 1 and 2, and a quarter 3 key to the quarter 3 discards at length.

Ages of survey and commercial-caught haddock were separately assigned by the DFO and the NMFS age readers, L. Van Eeckhaute and S. Sutherland, respectively. Inter-reader agreement testing between the NEFSC and DFO labs and intra-reader testing at both labs was undertaken. Overall, high agreement was attained, indicating that age determinations at both labs continue to be reliable. Details can be found in Sutherland et al 2007. Age reader agreement was judged to be satisfactory for estimating catch at age.

The 2006 Canadian and USA landings and discards at age estimates by quarter (Table 9 and Figure 8) were summed to obtain the quarterly and annual catch at age and appended to the 1969-2005 catch at age data (Van Eeckhaute and Brodziak 2006). Combined Canada/USA annual catch at age and average Canadian fishery weights and lengths at age are summarized in Tables 10, 11 and 12 and Figures 9 and 10. Canadian and USA fishery weights and lengths at age for 2006 are presented in Table 13. The 2000 year class (age 6), which contributed 56% of the total catch by numbers, again dominated the fishery in 2006 (Figure 11). Age 6 haddock, the dominant age group for both countries, account for 77% of USA landings compared to 57% of the Canadian landings (Figure 8). USA discards represented 48% by numbers of the USA catch, but only 2% by numbers of the combined Can/USA catch. Seventy-nine percent of the USA discards were age 3 haddock.

In 2005, the exceptional 2003 year class had been expected to make up 66% in numbers of the total EGB catch based on the projection, but the catch of that year class was only 28% of the observed catch (Figure 11). The shortfall was due to lower than anticipated recruitment of that age group to the fishery. As a result, the 2000 year class and older year classes made up a much higher percentage of the catch than anticipated, 67% instead of 30%.

The dominant age group in the fishery has increased from ages 2 and 3 during earlier periods to age 4 in recent years due primarily to a change in mesh type and an increase in mesh size. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year classes which continued to contribute substantially at ages 6 and older (Figure 12).

Abundance Indices

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each fall (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figures 13 and 14). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Vessel and door type conversion factors (Table 14), derived experimentally from comparative fishing, have been applied to the survey results to

make the series consistent (Forrester et al 1997). Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock.

In 2006, it was necessary to use six sets that were conducted by the *Teleost* (the *Alfred Needler* is the vessel usually used for this survey) in stratum 5Z3 to obtain proper coverage for the DFO survey. Although preliminary examination of comparative fishing experiments between the *Teleost* and *Needler* indicated that a conversion factor might be warranted, and was used in the previous assessment for these six tows, it was considered preferable to use unconverted data for the current assessment until more thorough analyses and review are conducted. The impact of applying a conversion factor of 1.17 to these 6 tows in the previous assessment, to make them equivalent to Needler tows, resulted in a very small change (1%) to the 2006 survey index.

The 2006 NMFS fall survey did not have any sets completed in stratum 20. A catch value of zero was assigned to this stratum as very few or no haddock have been caught in this stratum in recent years.

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for fall) in the most recent surveys is plotted to show the distribution in comparison to the average over the previous 10 year period (Figures 15, 16 and 17). Ages 2+ in the NMFS 2006 fall survey were abundantly distributed in 5Zj with some good catches on the southern flank as well. The DFO 2007 February survey found adult fish (ages 3+) abundantly and widely distributed on the Canadian side of the bank but catches on the USA side were much more scattered and scarce. However, a month later, during the NMFS spring survey, adult fish were found in large quantities on the US side as well as the Canadian side. Catches of the 2006 year class were sporadic for all three surveys but a few good tows were seen by the DFO survey on the southern flank. Good catches of the 2005 year class were made during all three surveys. In the fall, this year class was widely distributed on the Canadian side. In Feb, the DFO survey found them in highest concentrations on the southern flank and the NMFS spring survey also made good catches there as well as along the northern edge. The spring distribution of age 2 haddock was somewhat atypical as this age group is usually found most abundantly on the northern edge at this time of year.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year class strengths well (Tables 15, 16 and 17; Figure 18). Some year effects are evident. For example, low spring catches occurred in both the 1997 DFO and NMFS surveys. Survey biomass indices (ages 2-8 in fall; 3-8 in spring) peaked during the early 1960s (Figure 19). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Biomass generally increased during the 1990s. Since about 2003, the biomass indices have seen significant fluctuation with a large increase in 2007 for the NMFS spring survey, a small increase in the NMFS fall survey and a decrease in the DFO survey.

All three survey series indicate that the 2003 year class is one of the strongest on record with the age 4 indices for the spring surveys and the age 3 index for the fall survey the highest for those series for those ages. The 3 new survey observations for

the 2005 year class include 2 observations that are intermediate between the previous year's values and one that is near the previous year's lowest value supporting the view that it is an above average year class (Figure 20).

Growth

Canadian fishery weights at age (Table 11, Figure 10) in 2006 declined for ages 2 to 7, but, 2007 DFO survey weights at age (Table 18 and Figure 10) and lengths at age (Table 19 and Figure 21) generally increased, interrupting a downward trend that started after the mid-1990s for the older ages and around 2001 for the younger ages. The 2007 DFO survey length and weight at age 9+ are low due to being dominated by ages 9 and 10 which have low values for both characteristics. Average size at age has declined substantially so that haddock of age 2 and older are now at or smaller than the size that the next younger age group was in previous years before the declines occurred.

Weights at age from the DFO survey are considered beginning of year population weights and are calculated using the method in Gavaris and Van Eeckhaute (1998) in which weights observed during the survey are weighted by population numbers at length and age. Fishery weights at age are derived from the sampled lengths at age and a length-weight relationship (Waiwood and Neilson 1985).

Harvest Strategy

The Transboundary Management Guidance Committee (TMGC 2003) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.26. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

Estimation of Stock Parameters

Calibration of Virtual Population Analysis (VPA)

Tuned virtual population analysis was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey data. Details of the model formulations and model assumptions can be found in Gavaris and Van Eeckhaute (1998).

The VPA was based on quarterly catch at age, $C_{a,t}$ for ages a = 0, 1, 2...8, 9+, and time t = 1969.0, 1969.25, 1969.5, 1969.75, 1970.0...2006.75 where t represents the beginning of the time interval during which the catch was taken. Catch at age 0 (i.e., discards) was included in the catch at age. The population was calculated to the beginning of 2007. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$ for

s = DFO, ages a = 1, 2, 3...8, time t = 1986.16, 1987.16... 2006.16, 2007.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3...8, time t = 1969.29, 1970.29, 1971.29, 1972.29, 1982.29, 1983.29...2006.29, 2007.00

s = NMFS spring (Yankee 41), ages a = 1, 2, 3...8, time t = 1973.29, 1974.29...1981.29

s = NMFS fall, ages a = 0, 1, 2...5, time t = 1969.69, 1970.69...2006.69

Since the population is calculated to beginning year 2007, the NMFS and DFO spring surveys in 2007 were designated as occurring at time 2007.00 Other details of the tuning setup were the same as those used in the previous assessment and can be found in Van Eeckhaute and Brodziak 2006.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at age 1 exhibited a large relative error of 61% and a large relative bias of 16%, while the relative error for other ages was between 26% and 41% with a relative bias between 3% and 6% (Table 20). The relative bias on fishing mortality for ages 4 and older in 2006 was small at about 2%. While trends in the three surveys are generally consistent, the survey indices exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a substantial impact on estimates of current abundance (Figures 22-26). Some patterns in the residuals (by cohort and by age) suggest year class and/or year effects.

Retrospective Analysis

Retrospective analyses were used to detect any patterns to consistently overestimate or underestimate fishing mortality, biomass and recruitment relative to the terminal year estimates. This stock assessment does not display a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998, 2000 and 2003 year classes, successive estimates of year class abundance at age do not display any persistent tendency to be higher or lower (Figure 27). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 28).

State of Resource

The state of the resource was based on results from an age structured analytical assessment (VPA) that used fishery catch statistics and sampling for size and age composition of the catch (landings plus discards) for 1969 to 2006. The VPA was calibrated to trends in abundance from three bottom trawl survey series; NMFS spring, NMFS fall and DFO. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 21, 22 and 23). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 18) were used to calculate beginning of year population biomass (Table 23). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-85. Data to approximate the age composition of the catch

from unit areas 5Zj and 5Zm during 1931 to 1955 were used to reconstruct a population analysis of EGB that was suitable for comparison of productivity.

The adult (ages 3+) biomass trend compared favorably with the survey adult biomass trends (scaled with catchabilities) (Figure 29). Population biomass (ages 3+) increased to 39,000 mt during the late 1970s and early 1980s due to recruitment of the strong 1975 and 1978 year classes whose abundances were estimated to be above 50 million age-1 fish each (Figure 30). However, biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two cohorts were fished intensely at young ages. Improved recruitment in the 1990s and the strong 2000 year class, lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near an historical low of 8,500 mt in 1993 to 69,500 mt in 2003. Adult biomass subsequently decreased to 46,900 mt in 2005 but increased in 2006 and 2007 and is now at 145,300 mt (80% Confidence Interval: 113,276 – 200,206 mt), higher than the 1931-1955 maximum biomass of about 90,000 mt. The marked increase is due to the exceptional 2003 year class, estimated at 122,900 mt at age 4. Older ages sustained the fishery in 2006 but the exceptional 2003 year class is expected to contribute substantially to the catch weight in 2007.

Recruitment improved in the 1990s and the exceptional 2003 year class, estimated at 321 million age-1 fish, is the largest in the assessment time series (1931-1955 and 1969-2005). The 2000 year class (69 million at age 1) is estimated to be larger than the strong 1975 and 1978 year classes (Figure 30). In contrast, the 2001, 2002 and 2004 year classes, at less than 8 million fish, are below the 18 million average of the 10 most recent year classes (excluding the 2003 year class), while the 2005 year class at 31 million is above the 10-year average. Initial estimates of the 2006 year class suggest that it is about the size of the 2004 year class.

Fishing mortality for ages 4+ (weighted by population abundance) fluctuated between 0.2 and 0.4 during the 1980s (Figure 31) and markedly increased between 1989 and 1993 to about 0.6, the highest observed. Since 1995, fishing mortality had been below the reference, $F_{ref} = 0.26$, but increased in 2005 and 2006 to above F_{ref} ($F_{2006} = 0.36$; 80% Confidence Interval: 0.28 – 0.49).

The partial recruitment at age for EGB haddock has decreased in recent years (Tables 24 and 25; Figure 32) and, consequently, fishing mortality based on ages 5+, as fully recruited, has been higher than F for ages 4+ since 2003 (Figure 31). Lower weights at age have resulted in a reduced partial recruitment so that age 4 is now no longer fully recruited to the fishery. Therefore, partial recruitment estimates for ages 1 to 4 for recent years are more appropriately normalized on ages 5-8 (Table 26). Due to the magnitude of the 2003 year class, the partial recruitment pattern used for this year class will have a significant impact on estimates of the magnitude and composition of future catches.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock, which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Since 1993,

except for 1996, 2001, 2003 and 2004, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded fishery harvest yields, resulting in net population biomass increases (Figure 33). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year classes enter the population, e.g. the 2000 year class in 2002 and the 2003 year class in 2005 (Figure 34). The biomass contributed by the 2003 year class, both when it recruited at age 2 and through growth during that year was greater than that of any other previous cohort since 1969.

Productivity

Stock characteristics such as recruits per spawner, age structure, spatial distribution and fish growth reflect changes in the productive potential.

Stock-recruitment data indicates that the chance of a good year class is significantly enhanced for adult biomass above about 40,000 mt (Figure 35). Since 1969, only the 1975, 1978, 2000 and 2003 year classes have been above the average abundance of year classes observed during the period 1931-55. The recruits per adult biomass ratio was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 36), when the 3+ biomass was above 40,000 mt. Since 2001, with the exception 2003 and 2005, recruits per spawner have again been low.

In both absolute numbers and percent composition, the population age structure displays a broad representation of age groups (Figure 35), reflecting improving recruitment and lower exploitation, particularly at younger ages, since 1995.

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years. However, consistent with the pattern observed for previous large year classes, the exceptional 2003 year class, the main component of the 3+ age group, was widely distributed throughout the survey area (Figures 15, 16 and 17).

Both length and weight at age have declined since about 2000. While size at age increased in 2007 for most ages, weights remained about 40% to 50% below the average during 1986 to 2000. The size at age for the 2003 year class is smaller than previous year classes. DFO survey average weights at length, used to reflect fish condition, exhibit a declining trend but improved in 2007 (Figure 38).

In summary, with expanded age structure, broad spatial distribution and generally higher recruit per spawner ratio, resource productivity is high, negatively impacted only by recent reductions in fish size at age.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2008. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding F_{ref}=0.26. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are

dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough.

As in the previous assessment for this stock, the 2003 year class will comprise a large portion of the catch for the projected year, 2008. Predictions of weights at age and partial recruitment for this year class used for input into the risk assessment are very influential for catch projections.

For projections, the weights at age for the 2003 year class were derived by accounting for recent trends in reduced growth rate, as demonstrated by the 1998, 1999 and 2000 year classes (Figure 39), as was done for the previous assessment (Van Eeckhaute and Brodziak 2006). Data points at younger ages were excluded as the addition of these points changed the functional relationship from linear to curvilinear. The predicted growth rate at length was applied to the 2007 DFO survey average length for the 2003 year class (41 cm at age 4) to obtain the beginning of year length at age 5, i.e. $L4=L3 \times e^{growth\ rate}$, and then sequentially, at age 6 using the growth rate predicted for the length at age 5 (Table 26). Average fishery lengths were determined from the relationship between beginning year length (from the DFO survey) and the fishery length in the same year using data from 1995 to 2006 (Figure 40). The resulting 2003 year class predicted lengths used for the population and fishery are compared to other year classes in Figure 41. The length estimates were then converted to weights using the length weight relationship used to convert the Canadian fishery lengths to weights (Waiwood and Neilson 1985). Beginning of year weights at age were reduced by 10% to account for the observed reduction in observed weights relative to those derived from the length weight relationship (Table 27). Weights at age for the fishery, derived from the length weight relationship, were considered appropriate as this relationship is based on fishery data (Table 28). The 2006 observed fishery weights were used for year classes preceding and following the 2003 year class.

The Canadian groundfish fishery switched from diamond mesh to square mesh around 1995. The relationship between partial recruitment values from 1995 to 2006 and fishery weights, which reflect fishery lengths, was used to determine partial recruitment values (Figure 42). A drop in age 4 partial recruitment compared to age 5 is observed after 2002 (Table 24). Therefore, for Figure 42, the 1995 to 2002 partial recruitment values were based on ages 4-8 as fully recruited while the 2003 to 2006 values were based on ages 5-8. Values of 0.2 for age 4 in 2007 and 0.52 for age 5 in 2008 were judged to be appropriate for the 2003 year class for the catch projection.

A risk assessment was conducted to beginning year 2009 incorporating these patterns in growth and partial recruitment. Stock size estimates at the beginning of 2007 were used to start the forecasts. Abundances of the 2007 and 2008 year classes were assumed to be 20 million at age 1, which is near the previous 10-year average (2003 year class excluded). Natural mortality was assumed to be 0.2 (Table 29). Assuming a 2007 catch equal to the 19,000 mt total quota, a combined Canada/USA catch of 26,700 mt in 2008 would result in a neutral risk (50%) that the fishing mortality rate in 2008 will exceed $F_{ref} = 0.26$ (Figure 42). A catch of 23,000 mt would result in a low risk (25%) that the fishing mortality rate in 2008 will exceed F_{ref}. Adult biomass is projected

to be 151,000 mt at the beginning of 2009 a drop of 7% from the previous year (Table 30). The 2003 year class (age 5) will comprise the highest proportion of the total 2008 yield accounting for 86% of the catch in weight, 88% by numbers, at the 26,700 mt level. Ages 6+ are expected to account for 12% of the catch biomass, 9% by numbers.

Special Considerations

The outstanding 2003 year class was expected to contribute 66% of the 2006 catch numbers but accounted for only 28%. The contribution was less than predicted due to lower than anticipated recruitment to the fishery. The failure of this year class to contribute as expected to the fishery resulted in more of the 2000 and older year classes being caught in 2006 than had been projected from the 2005 assessment. This generated a fishing mortality above F_{ref} on the older ages in 2006. Slow growth of the 2003 cohort will continue to impact the fishery. If the TAC in 2007 is caught, fishing mortality will, again, be higher than F_{ref} on the fully recruited ages (F_{5+}=0.33) because the 2007 age 4 fishery partial recruitment is now estimated at 0.2 compared to 0.3, the value used in the 2006 assessment.

While best judgment was used to determine the fishery partial recruitments for the reduced weight of the 2003 year class, the risk analysis does not capture the extent of uncertainty of the consequences for various catch levels. To characterize the dependence of the projection results on the fishery partial recruitment for the 2003 year class, a sensitivity analysis was done to augment the risk analysis. Using the observed range of partial recruitment at fishery weight during 1995 to 2006, the 2008 projected catch could vary from 17,000 mt to 31,000 mt. If the realized partial recruitment is near the higher end of the observed partial recruitment range, the fishery could forego available yield, if it is lower, the 4+ fishing mortality could be higher than F_{ref}.

Cod and haddock are often caught together in groundfish fisheries, although their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

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Table 1. Nominal catches (mt) of haddock from EGB during 1969-2006. For "Other" it was assumed that 40% of the total 5Z catch was in EGB.

	Landings			Discards		Total	Quotas	
Year	Canada	USA	Other	Canada	USA	Catch	Canadian	USA
1969	3941	6622	695	123		11381		
1970	1970	3153	357	116		5596		
1971	1610	3534	770	111		6025		
1972	609	1551	502	133		2795		
1973	1565	1396	396	98		3455		
1974	462	955	573	160	757	2907		
1975	1353	1705	29	186		3273		
1976	1355	973	24	160		2512		
1977	2871	2429		151	2966	8417		
1978	9968	4724		177	1556	16425		
1979	5080	5211		186		10477		
1980	10017	5615		151	7561	23344		
1981	5658	9077		177		14912		
1982	4872	6280		130		11282		
1983	3208	4454		119		7781		
1984	1463	5121		124		6708		
1985	3484	1683		186		5353		
1986	3415	2200		92		5707		
1987	4703	1418		138		6259		
1988	4046	1693		151		5890		
1989	3060	787		138		3985		
1990	3340	1189		128		4657		
1991	5456	949		117		6522		
1992	4058	1629		130		5817	5000	
1993	3727	421		114		4262	5000	
1994	2411	33		114	258	2816	3000	
1995	2065	22		69	25	2181	2500	
1996	3663	36		52	41	3792	4500	
1997	2749	48		60	63	2919	3200	
1998	3371	311		102	14	3798	3900	
1999	3681	355		49		4084	3900	
2000	5402	187		29		5618	5400	
2001	6774	604		39	40	7457	6989	
2002	6488	914		29	35	7465	6740	
2003	6775	1564		98	63	8500	6933	
2004	9745	1796		93	156	11790	9900	5100
2005	14484	512		52	57	15112	15410	7590
2006	11984	445		67	146	12642	14520	7480

[1] 1895 mt excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and EGB fishery management units by the USA and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
1984 Oct.	Implementation of the 'Hague' line .	
1985	5 ½" mesh size, Areas 1 and 2 closed February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		EGB adopted as management unit. For MG < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of ITQs and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from Jan 1-June30.	OT fishery permitted to operate in Jan. and Feb. Increase in use of square mesh. TAC = 5000 mt.
1994	Jan.: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishng until July 1. Predominantly square mesh by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh. Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock, pollock, hake or cusk combined can participate in 5Z fishery. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt. Restrictions on catching of cod and haddock under 43 cm (small fish protocol).
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
1997	May: Additional scheduled Days-at-sea restrictions.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on

	USA	Canada
	September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3,200 mt.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3,900 mt.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	TAC = 3,900 mt.; mandatory cod separator panel when no observer on board.
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in Oct. 2003.	TAC = 6,933 mt for 2003.
Canada – USA Resource Sharing Agreement on Georges Bank		
2004	May 1, day and trip limits removed. TAC = 5,100 mt. Oct. 1: unit areas 561 and 562 closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC= 7,590 mt. Jan. 14: cod separator trawl required.	TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 18, 2005.
2006	TAC= 7,480 mt; Closed in first half of year when cod quota nearly reached.	TAC = 14,520 mt; exploratory winter fishery Jan. to Feb. 6, 2006.

Table 3. Canadian landings (mt) of haddock from EGB during 1969-2006 by gear category and tonnage class for principal gears.

Year	Otter Trawl							Longline				Scallop Fishery	Other	Total
	Side	Stern												
		1[3]	2	3	4	5	Total	1[3]	2	3	Total			
1969	777		0	1	225	2902	3127		2	21	23	15	0	3941
1970	575		2	0	133	1179	1314		6	72	78	2	1	1970
1971	501		0	0	16	939	955		18	129	151	3	0	1610
1972	148		0	0	2	260	263		23	169	195	1	2	609
1973	633		0	0	60	766	826		23	80	105	0	1	1565
1974	27		0	6	8	332	346		29	59	88	1	0	462
1975	222		0	1	60	963	1024		25	81	107	0	0	1353
1976	217		0	2	59	905	967		48	108	156	0	15	1355
1977	370		92	243	18	2025	2378		43	51	94	1	28	2871
1978	2456		237	812	351	5639	7039		121	47	169	17	287	9968
1979	1622		136	858	627	1564	3185		190	80	271	2	0	5080
1980	1444		354	359	950	6254	7917		129	51	587	4	65	10017
1981	478		448	629	737	2344	4159		331	99	1019	1	1	5658
1982	115		189	318	187	3341	4045		497	187	712	0	0	4872
1983	106		615	431	107	1130	2283		593	195	815	1	3	3208
1984	5		180	269	21	149	620		614	192	835	2	1	1463
1985	72		840	1401	155	348	2745		562	33	626	2	39	3484
1986	51		829	1378	95	432	2734		475	98	594	4	32	3415
1987	48		782	1448	49	1241	3521		854	113	1046	38	50	4703
1988[2]	72		1091	1456	186	398	3183		428	200	695	16	80	4046
1989	0		489	573	376	536	1976		713	175	977	12	95	3060
1990	0		928	890	116	471	2411		623	173	853	7	69	3340
1991	0		1610	1647	81	689	4028		900	271	1309	8	111	5456
1992	0		797	1084	56	645	2583		984	245	1384	4	87	4058
1993	0		535	1179	67	699	2489		794	156	1143	2	93	3727
1994	0		495	911	79	112	1597		498	47	714	9	91	2411
1995	0		523	896	14	214	1647		256	75	390	7	21	2065
1996	1		836	1405	166	270	2689		561	107	947	0	26	3663
1997	0		680	1123	91	96	1991		501	116	722	0	36	2749
1998	0		863	1340	98	71	2422		570	252	921	0	28	3371
1999	0		954	1471	174	145	2761		486	241	887	0	32	3680
2000	0		1313	2269	230	246	4146		619	258	1186	0	70	5402
2001	0		1564	2555	0	757	5112		754	302	1633	0	29	6774
2002	0		1217	2720	0	657	4954		794	151	1521	0	12	6488
2003	0		1186	3246	0	0	4985		806	249	1776	0	14	6775
2004	0		2152	4651	0	67	7744		716	223	2000	0	1	9745
2005	0	1467	2929	7393	326	0	12115	1645	646	78	2368	0	1	14484
2006	0	1605	1805	6076	601	0	10088	1321	491	84	1896	0	1	11984

[1] Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

[2] Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

[3] Tonnage class 1 landings included in 'Total'. Historically, tonnage class 1 accounted for a low proportion of total otter trawl landings but the proportion has increased in recent years..

Table 4. Monthly landings (mt) of haddock by Canada from EGB during 1969-2006.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988[1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1703	983	1364	820	593	452	6488
2003	0	0	0	0	0	840	1767	1290	930	952	676	320	6775
2004	0	0	0	0	0	1547	2268	2109	1753	1275	556	236	9745
2005	1025	1182	0	0	13	1423	3004	3820	2199	1198	357	266	14484
2006	1176	381	0	0	0	1093	2433	2668	2211	1149	558	316	11984

[1] Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. Monthly landings (mt) of haddock by the USA from EGB during 1969-2006. Details for 1994-2006 are not available because data are preliminary.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	261	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421
1994													33
1995													22
1996													36
1997													48
1998													311
1999													355
2000													187
2001													604
2002													914
2003													1564
2004[1]		266			1196			307			27		1796
2005[1,2]		40			322			149			1		512
2006		47			393			5			0		445

[1]Landings by quarter.
[2]Fishery was closed in August when cod by-catch quota reached.

Table 6. USA landings (mt) of haddock from EGB during 1969-2006 by gear category and tonnage class. Details for 1994-2006 are not available because data are preliminary.

Year	Otter Trawl			Other	Total
	3	4	Total		
1969	3010	3610	6621	0	6622
1970	1602	1551	3154	0	3153
1971	1760	1768	3533	0	3534
1972	861	690	1551	0	1551
1973	637	759	1396	0	1396
1974	443	512	955	0	955
1975	993	675	1668	36	1705
1976	671	302	972	2	973
1977	1721	700	2423	5	2429
1978	3140	1573	4713	11	4724
1979	3281	1927	5208	4	5211
1980	3654	2955	5611	4	5615
1981	3591	5408	9031	45	9077
1982	2585	3657	6242	37	6280
1983	1162	3261	4423	29	4454
1984	1854	3260	5115	5	5121
1985	856	823	1679	4	1683
1986	985	1207	2192	9	2200
1987	778	639	1417	1	1418
1988	920	768	1688	6	1693
1989	359	419	780	6	787
1990	486	688	1178	4	1189
1991	400	517	918	13	931
1992	597	740	1337	292	1629
1993	142	191	333	88	421
1994			32	0	33
1995			21	0	22
1996			36	0	36
1997			48	0	48
1998			311	0	311
1999			355	0	355
2000			187	0	187
2001			602	2	604
2002			913	1	914
2003			1564	0	1564
2004			1794	2	1796
2005			465	47	512
2006			414	31	445

Table 7. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2006 from EGB.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages[8]
				At Sea		Port		
				Trips	Measured	Samples	Measured	
1	OTB	Jan	1,171,238	27	17,802	5	1,235	
		Feb	381,127	4	2,131	1	240	Survey = 926[2]
	LL	Jan	4,663	1	397			
	DR[1]		3557	2	188			
2	OTB	June	1,067,499	71	58,839	9	2,238	
	LL	June	25,347	4	1,192			At Sea = 238
	GN	June	17					Port = 229
	DR[1]		17,146	3	422			Total = 467[3]
3	OTB	July	1,846,362	41	32,721	5	1,253	
		Aug	2,047,238	42	37,626	7	1,710	
		Sept	1,740,964	23	20,780	1	235	
	LL	July	585,697	10	9,820	3	653	
		Aug	620,883	7	6,796	4	905	At Sea = 458
		Sept	469,984	2	2,256	5	1,128	Port = 74
	GN	July	591					Total = 532[4]
		Aug	256					
	HL	Aug[6]	16					
	DR[1]		25,096	2	458			
4	OTB	Oct	1,006,156	15	15,136	7	1,505	
		Nov	513,454	23	16,818	6	1,376	
		Dec	313,559	14	12,810	2	475	At Sea = 189
	LL	Oct	142,591	2	2,090	3	632	Port = 271
		Nov[7]	44,488					Total = 460[5]
		Dec[7]	2,166					
	DR[1]		20,852	4	1135			
Totals			12,050,947	297	239,417	58	13,585	2,385

OTB=Otter Trawl Bottom, LL=Long Line, GN=Gill Net, HL=Hand Line, DR=Scallop Dredge
[1]Discards from the scallop fishery were estimated by quarter.
[2]Ages for 2 length groupings were estimated and are not included in the total.
[3]Ages for 5 length groupings were estimated and are not included in the total.
[4]Ages for 5 length groupings were estimated and are not included in the total.
[5]Ages for 7 length groupings were estimated and are not included in the total.
[6]Combined with August LL.
[7]Combined with October LL.
[8]Otoliths were not available for some lengths. Ages at these lengths with no otoliths sampled were estimated by comparing to other quarters and year class strengths.

Table 8. USA landings of haddock in 2006 by quarter and market category from EGB and NMFS sampling intensity for lengths and ages.

Market Category	Large	Scrod	Unclassified	Total
		Landings (mt)		
Quarter 1	30	17	0	47
Quarter 2	101	292	0	393
Quarter 3	1	4	0	5
Quarter 4	0	0	0	0
Total	132	313	0	446
		Length per 100 mt (Number measured)		
Quarter 1	0 (0)	0 (0)	0 (0)	0 (0)
Quarter 2	725 (732)	135 (396)	0 (0)	861 (1128)
Quarter 3	10833 (104)	0 (0)	0 (0)	10833 (104)
Quarter 4	0 (0)	0 (0)	0 (0)	0 (0)
Total	11559 (836)	135 (396)	0 (0)	11694(1232)
		Age per 100 mt (Number aged)		
Quarter 1	0 (0)	0 (0)	0 (0)	0 (0)
Quarter 2	391 (395)	67 (196)	0 (0)	458 (591)
Quarter 3	5104 (49)	0 (0)	0 (0)	5104 (49)
Quarter 4	0 (0)	0 (0)	0 (0)	0 (0)
Total	5496 (444)	67 (196)	0 (0)	5563 (640)

Table 9. Components of the 2006 catch at age in numbers (000s) of haddock from EGB by quarter.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
Canadian Landings											
2006	0	0	0	14	4	33	665	33	83	15	846
2006.25	0	0	0	97	4	17	455	33	56	6	666
2006.5	0	0	2	1191	24	200	2589	117	344	96	4563
2006.75	0	0	1	737	5	27	608	36	49	35	1497
Year total	0	0	3	2039	36	277	4316	218	532	151	7573
USA Landings											
2006	0	0	0	0	0	0	0	0	0	0	0
2006.25	0	0	0	6	2	9	202	12	19	6	256
2006.5	0	0	0	0	0	0	0	0	0	0	0
2006.75	0	0	0	0	0	0	0	0	0	0	0
Year total	0	0	0	6	2	9	202	12	19	6	256
Canadian Discards											
2006	0	0	0	1	0	0	1	0	0	0	3
2006.25	0	1	0	13	0	0	3	0	1	0	20
2006.5	1	3	1	29	0	0	1	0	0	0	35
2006.75	1	2	1	19	0	0	3	0	0	0	26
Year total	1	6	2	62	1	1	9	1	1	0	83
USA Discards											
2006	0	0	0	0	0	0	0	0	0	0	0
2006.25	0	7	6	221	3	2	32	3	3	0	277
2006.5	0	0	0	2	0	0	1	0	0	0	4
2006.75	0	0	0	0	0	0	0	0	0	0	0
Year total	0	7	6	223	3	2	33	3	3	0	281
Total											
2006	0	0	0	15	4	33	666	33	84	15	849
2006.25	0	8	6	337	10	28	692	49	78	12	1220
2006.5	1	3	3	1223	24	201	2591	117	344	96	4602
2006.75	1	2	2	756	5	27	611	36	49	35	1523
Year total	1	14	11	2330	43	289	4559	234	555	157	8194

Table 10. Total annual commercial catch at age numbers (000's) of haddock from EGB during 1969-2006. Estimates of discards are included.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
1969	6	0	18	1451	262	334	2909	831	91	283	6184
1970	0	66	84	7	351	151	130	1153	372	193	2508
1971	43	0	1201	251	31	252	159	161	774	412	3284
1972	118	346	1	390	72	21	94	39	16	451	1547
1973	7	1119	1758	6	364	38	10	39	8	169	3517
1974	9	37	2257	276	0	32	3	0	29	63	2706
1975	553	18	279	1504	216	5	36	2	2	31	2645
1976	1	402	157	173	834	135	0	19	0	18	1739
1977	0	1	8028	66	182	307	164	0	15	15	8778
1978	110	6	291	9956	164	173	306	80	10	9	11105
1979	12	212	17	208	4307	364	201	217	43	14	5597
1980	31	32	17701	343	302	2425	193	130	52	12	21220
1981	6	55	693	6773	400	497	1243	119	33	7	9826
1982	1	2	731	1057	2848	205	379	730	62	65	6080
1983	75	11	149	663	554	1653	208	104	409	35	3860
1984	1	72	100	259	350	270	1131	186	166	318	2854
1985	353	9	2146	386	182	199	128	381	53	117	3954
1986	0	89	39	2586	175	143	124	119	174	42	3492
1987	19	0	2081	131	1536	100	58	83	70	111	4190
1988	1	53	53	2199	124	894	111	39	46	100	3619
1989	8	2	1270	85	757	132	326	31	21	45	2677
1990	18	31	8	1334	128	755	69	166	42	42	2593
1991	35	22	466	92	2080	90	393	73	146	61	3458
1992	151	49	249	323	128	1464	89	319	26	91	2891
1993	4	80	283	351	282	87	645	34	155	75	1997
1994	13	34	304	762	153	56	49	129	29	40	1568
1995	4	8	83	546	420	54	26	3	52	17	1213
1996	6	4	34	496	872	424	61	18	3	73	1992
1997	1	30	103	85	549	488	196	13	8	34	1507
1998	19	19	198	295	265	547	453	116	12	35	1960
1999	2	27	44	752	319	248	346	255	99	25	2117
2000	1	6	318	443	1249	250	201	209	182	65	2924
2001	0	23	67	1719	525	831	255	199	226	194	4041
2002	0	1	358	222	1862	370	657	110	106	278	3964
2003	486	5	9	1806	281	1459	419	470	107	227	5269
2004	2	249	18	63	3602	588	1482	513	418	260	7195
2005	0	11	210	29	222	6831	519	804	126	154	8905
2006	1	14	11	2330	43	289	4559	234	555	157	8194

Table 11. Average weight at age (kg) of haddock from the Canadian commercial groundfish fishery from EGB during 1969-2006. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.417	1.762	1.940	2.339	2.657	2.377
2003	0.475	0.758	1.381	1.589	1.851	1.894	2.343	2.839
2004	0.482	0.589	1.102	1.514	1.643	1.880	2.002	2.282
2005	0.056[1]	0.697	0.989	1.433	1.685	1.857	2.041	2.059
2006	0.335	0.514	0.977	0.978	1.603	1.783	1.872	2.019
Low	0.335[2]	0.514	0.812	0.978	1.603	1.631	1.872	2.019
High	0.797[2]	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600[2]	0.984	1.374	1.786	2.131	2.498	2.860	3.099
Average	0.577[2]	0.970	1.356	1.766	2.115	2.437	2.768	3.020
2004-06	0.409[2]	0.600	1.023	1.308	1.644	1.840	1.971	2.120

[1]One haddock measured.
[2]Excludes 2005 value.

Table 12. Average lengths at age (cm) of haddock from the EGB Canadian commercial fishery during 1969-2006. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1985		43.2	47.6	56.1	56.8	63.6	66.3	65.8
1986	33.7	43.8	50.1	56.2	63.4	62.8	68.7	72.3
1987		41.4	49.2	56.6	57.5	60.2	62.9	68.2
1988	32.8	43.7	48.4	53.7	58.1	58.1	64.1	64.1
1989		41.8	49.7	53.8	57.8	61.2	62.3	64.1
1990	37.9	43.5	50.2	52.9	58.0	57.8	62.0	59.3
1991	36.2	47.0	47.0	54.2	56.0	61.5	58.9	63.2
1992	35.7	46.4	52.6	52.6	58.1	56.3	64.0	61.2
1993	38.3	46.4	53.4	58.1	56.9	61.6	64.0	65.1
1994	32.5	46.1	52.6	58.1	61.6	59.5	62.8	65.4
1995	40.2	45.0	50.8	56.2	60.8	62.4	63.5	64.2
1996	36.4	44.5	50.0	53.8	58.6	60.0	66.6	56.5
1997	38.6	47.2	48.8	53.4	57.0	60.2	64.4	66.9
1998	36.5	46.1	51.6	52.8	55.7	58.7	63.3	67.2
1999	38.7	45.6	51.5	55.1	54.5	57.4	60.5	62.4
2000	38.5	45.6	50.4	55.2	58.2	56.3	59.9	62.6
2001	32.1	45.5	50.4	53.5	56.9	59.2	57.6	60.3
2002	32.5	44.3	49.7	53.5	55.2	58.9	61.5	59.0
2003	34.2	40.2	49.3	51.6	54.4	54.8	58.9	63.1
2004	34.5	36.9	45.6	50.8	52.3	54.7	55.9	58.3
2005	16.5[1]	38.8	44.0	49.8	52.8	54.5	56.1	56.3
2006	30.4	35.2	43.7	43.9	51.9	53.8	54.7	56.0
Low	30.4[2]	35.2	43.7	43.9	51.9	53.8	54.7	56.0
High	40.2[2]	47.2	53.4	58.1	63.4	63.6	68.7	72.3
Median	35.7[2]	44.4	49.8	53.7	56.9	59.1	62.6	63.1
Average	34.5[2]	43.6	49.4	53.7	56.9	58.8	61.8	62.8
2003-05	34.5[2]	43.6	49.5	53.6	56.9	58.6	61.6	62.7

[1]One haddock measured.
[2]Excludes 16.5 cm value in 2005.

Table 13. Weights and lengths at age for USA and Canadian commercial haddock fisheries on EGB in 2006.

	Age Group								
	1	2	3	4	5	6	7	8	9+
Weights									
USA landings			1.062	0.985	1.465	1.691	1.753	2.339	2.757
USA discards	0.103	0.202	0.399	0.611	1.119	1.264	1.117	1.224	1.819
USA catch	0.103	0.202	0.415	0.759	1.395	1.631	1.632	2.192	2.724
Canadian landings	0.335	0.514	0.977	0.978	1.603	1.783	1.872	2.019	2.211
Canadian discards	0.237	0.376	0.743	1.013	1.284	1.658	1.789	2.132	2.113
Lengths									
US landings			47.8	46.6	52.8	55.3	55.9	61.4	64.8
US discards	22.4	27.9	34.9	40.5	48.9	50.9	48.7	50.0	57.6
US catch	22.4	27.9	35.2	42.9	52.0	54.7	54.5	59.9	64.6
Canadian landings	30.4	35.2	43.7	43.9	51.9	53.8	54.7	56.0	57.7
Canadian discards	26.5	31.6	39.6	44.5	47.6	52.3	53.8	56.8	56.8

Table 14. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2007.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1
2006	Polyvalent	Albatross IV	1	Albatross IV	1
2007	Polyvalent	Albatross IV	1		

Table 15. Total swept area estimates of abundance at age (numbers in 000's) of EGB haddock from DFO surveys during 1986-2007.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12659	2980	2644	647	528	2420	56760
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883
2005	1669	20958	531	1557	25559	3403	4815	1087	548	60125
2006	9130	5817	178604	2521	2251	15695	764	1633	261	216675
2007	3051	9541	3289	67311	984	154	3584	251	652	88816

Table 16. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from NMFS spring surveys during 1968-2007. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104
2005	540	32911	257	614	5818	671	1196	240	67	42313
2006	2961	1247	48882	213	949	6650	325	574	187	61988
2007	1468	11383	2055	95882	180	441	2168	222	312	114110

Table 17. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from NMFS fall surveys during 1963-2006. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	652	6656	3601	585	0	87	96	30	0	11707
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613
2004	2864	116289	322	775	17200	1034	2410	416	528	141837
2005	4981	3114	95159	340	532	3631	347	242	155	108502
2006	930	8752	1040	65817	1083	82	796	0	16	78517

Table 18. Average weight at age (kg) of EGB haddock from DFO surveys during 1986-2007, which are used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
2005	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.444
2006	0.059	0.171	0.389	0.657	0.870	1.366	1.591	1.742	2.355
2007	0.077	0.246	0.405	0.709	0.992	1.745	1.559	1.671	1.862
Low	0.028	0.171	0.389	0.657	0.870	1.321	1.531	1.600	1.862
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.107	0.478	0.915	1.305	1.746	2.113	2.298	2.650	3.150
Average	0.103	0.449	0.847	1.285	1.699	2.071	2.370	2.603	3.070
2005-07	0.054	0.211	0.429	0.688	1.029	1.477	1.560	1.671	2.221
1991-2000	0.118	0.528	0.975	1.401	1.749	2.187	2.523	2.780	3.252

Table 19. Average lengths at age (cm) of EGB haddock from DFO surveys during 1986-2007.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	22.9	36.2	45.4	51.0	63.7	61.9	67.8	66.0	70.7
1987	24.2	36.3	39.7	53.4	57.1	61.1	65.1	65.8	69.6
1988	22.3	36.4	45.1	55.7	55.9	58.0	62.4	65.8	71.5
1989	19.5	35.9	39.1	50.4	56.8	61.3	58.0	64.6	66.3
1990	24.7	35.8	44.4	48.0	55.9	58.7	61.6	63.1	67.5
1991	23.1	40.7	42.7	51.7	52.9	60.2	58.3	65.1	67.8
1992	23.2	39.2	47.7	46.8	57.7	62.5	63.9	60.3	68.1
1993	23.6	36.6	49.7	55.5	50.0	60.4	59.3	63.7	67.3
1994	22.3	35.8	45.8	53.8	57.6	58.5	65.9	66.5	65.4
1995	20.2	36.3	45.1	52.7	59.0	62.5		65.0	66.0
1996	24.2	36.2	44.4	50.1	56.9	62.7	66.2	61.8	68.4
1997	23.6	37.1	42.1	48.9	54.2	59.5	62.4	63.5	66.8
1998	21.8	37.6	46.4	47.3	52.9	57.2	62.5	69.3	68.7
1999	23.7	35.9	44.8	49.8	48.9	56.1	58.9	63.6	66.6
2000	22.7	37.6	44.3	52.1	56.4	54.7	59.6	61.7	64.7
2001	21.7	37.5	46.1	51.1	56.2	60.0	59.0	62.5	65.5
2002	21.5	31.8	42.1	47.5	52.0	58.1	60.3	59.2	64.4
2003	20.2	34.0	43.3	46.8	52.0	53.8	61.2	61.3	63.3
2004	19.1	31.8	42.0	47.9	50.6	53.3	55.3	59.1	60.2
2005	15.1	29.1	37.2	41.1	49.7	51.6	53.8	54.3	62.7
2006	18.7	27.0	34.0	40.2	42.6	51.8	52.8	55.7	62.2
2007	20.6	29.6	34.2	41.0	46.7	55.0	53.5	54.1	55.4
Low	15.1	27.0	34.0	40.2	42.6	51.6	52.8	54.1	55.4
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	22.3	36.2	44.3	50.0	55.0	58.6	60.3	63.3	66.5
Average	21.8	35.2	43.0	49.2	53.9	58.1	60.4	62.4	65.9

Table 20. Statistical properties of estimates of population abundance (numbers in 000's) at time 2007 and survey calibration constants (unitless, survey:population) for EGB haddock obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	9956	6068	0.609	1274	0.158
2	26684	10953	0.410	1756	0.057
3	5345	1684	0.315	138	0.064
4	181935	49695	0.273	8624	0.035
5	821	210	0.256	15	0.034
6	842	255	0.303	21	0.059
7	8295	2800	0.338	160	0.025
8	1034	346	0.334	50	0.046
		Survey Calibration Constants			
DFO Survey					
1	0.237	0.047	0.197	0.005	0.020
2	0.452	0.087	0.192	0.008	0.018
3	0.912	0.177	0.194	0.017	0.019
4	0.914	0.179	0.196	0.012	0.013
5	1.089	0.221	0.203	0.025	0.023
6	0.872	0.175	0.201	0.007	0.008
7	1.068	0.213	0.199	0.018	0.017
8	1.104	0.210	0.190	0.013	0.012
NMFS Spring Survey – Yankee 36 – 1969-72/1982-2006					
1	0.131	0.022	0.169	0.003	0.020
2	0.343	0.056	0.163	0.002	0.005
3	0.447	0.077	0.173	0.004	0.010
4	0.444	0.074	0.166	0.006	0.013
5	0.500	0.084	0.167	0.011	0.021
6	0.423	0.071	0.168	0.011	0.025
7	0.434	0.074	0.171	0.009	0.021
8	0.513	0.091	0.177	0.008	0.015
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.223	0.073	0.327	0.011	0.051
2	0.509	0.156	0.306	0.020	0.040
3	0.637	0.203	0.318	0.027	0.043
4	0.794	0.265	0.334	0.038	0.048
5	0.947	0.310	0.327	0.053	0.056
6	0.889	0.347	0.390	0.066	0.074
7	1.491	0.526	0.353	0.080	0.054
8	0.659	0.231	0.351	0.038	0.058
NMFS Fall Survey					
0	0.128	0.020	0.153	0.002	0.017
1	0.304	0.047	0.155	0.004	0.013
2	0.240	0.037	0.156	0.005	0.021
3	0.244	0.037	0.152	0.004	0.016
4	0.203	0.031	0.154	0.002	0.012
5	0.166	0.026	0.154	0.003	0.017

Table 21. Beginning of year population abundance (numbers in 000's) for EGB haddock during 1969-2007 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2007.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	796	195	3975	863	893	8421	2790	184	780	18896	18100	17905
1970	3469	651	143	1958	471	436	4309	1545	458	13441	9972	9321
1971	452	2772	455	111	1290	250	240	2493	1138	9199	8747	5975
1972	5615	370	1159	147	64	830	63	55	1922	10225	4610	4239
1973	11520	4274	302	600	56	33	598	17	1208	18608	7089	2815
1974	3390	8424	1897	242	159	12	19	454	846	15443	12053	3629
1975	3261	2739	4861	1311	198	102	7	15	985	13479	10218	7479
1976	54641	2650	1981	2617	880	158	52	4	790	63773	9133	6483
1977	5833	44348	2029	1468	1405	601	130	25	634	56474	50641	6293
1978	4133	4767	28983	1603	1040	883	349	106	514	42378	38244	33478
1979	52557	3376	3620	14540	1161	698	452	213	491	77108	24551	21174
1980	6655	42778	2746	2774	8055	624	396	180	525	64731	58076	15298
1981	5077	5411	19054	1942	2002	4464	340	212	520	39022	33945	28534
1982	1773	4098	3791	9548	1235	1196	2563	173	564	24943	23169	19071
1983	2627	1448	2677	2152	5251	825	642	1446	492	17559	14932	13484
1984	15226	2136	1046	1587	1263	2832	489	432	1196	26207	10981	8845
1985	1612	12384	1659	623	985	796	1318	237	906	20519	18907	6523
1986	13645	1309	8129	1001	345	629	538	743	784	27122	13477	12169
1987	1300	11077	1034	4345	666	156	405	337	1061	20380	19080	8004
1988	15516	1062	7182	729	2178	455	75	257	982	28437	12920	11858
1989	802	12637	822	3895	485	995	274	28	884	20822	20020	7383
1990	2506	654	9198	596	2505	279	523	197	688	17146	14640	13985
1991	1873	2019	528	6320	373	1372	167	280	649	13582	11709	9689
1992	8098	1512	1226	350	3285	224	770	73	575	16113	8014	6503
1993	11600	6574	1009	711	173	1379	106	344	425	22320	10720	4146
1994	12933	9417	5113	506	331	65	558	56	429	29411	16477	7060
1995	4602	10544	7428	3475	273	219	8	339	334	27223	22621	12077
1996	5748	3753	8547	5578	2460	174	156	4	488	26908	21159	17407
1997	16617	4692	3038	6535	3761	1621	85	111	333	36794	20177	15484
1998	7150	13546	3742	2408	4839	2625	1146	58	324	35839	28689	15143
1999	24784	5825	10892	2785	1725	3451	1729	833	270	52294	27510	21685
2000	8953	20220	4724	8212	1986	1184	2508	1183	791	49760	40807	20588
2001	69250	7308	16250	3456	5564	1398	784	1860	1388	107258	38008	30700
2002	3539	56549	5917	11700	2343	3781	907	457	2267	87459	83920	27372
2003	1967	2890	45928	4636	7844	1574	2483	641	1876	69839	67872	64982
2004	321691	1602	2352	35888	3534	5072	902	1598	1755	374395	52704	51102
2005	7820	262678	1295	1867	26016	2360	2792	271	2126	307224	299405	36726
2006	30519	6382	214524	1034	1326	15025	1463	1566	1713	273551	243032	236650
2007	8682	24929	5207	173311	807	820	8134	984	2034	224909	216227	191298

Table 22. Fishing mortality rate for EGB haddock during 1969-2006 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2007. The aggregated rates are weighted by population numbers. The rate for 4+ is also shown as exploitation rate (%).

Year	Age Group												
	1	2	3	4	5	6	7	8	9+	4+	4+ (%)	4-8	5-8
1969	0.001	0.110	0.508	0.405	0.517	0.470	0.391	0.762	0.500	0.459	33.6	0.456	0.460
1970	0.024	0.159	0.056	0.218	0.435	0.399	0.347	0.305	0.603	0.332	25.8	0.318	0.347
1971	0.000	0.672	0.926	0.352	0.241	1.170	1.280	0.411	0.495	0.459	33.6	0.450	0.453
1972	0.073	0.002	0.458	0.774	0.447	0.128	1.097	0.374	0.290	0.291	23.0	0.292	0.222
1973	0.113	0.612	0.023	1.128	1.352	0.379	0.074	0.744	0.163	0.406	30.4	0.630	0.206
1974	0.013	0.350	0.170	0.000	0.249	0.265	0.013	0.071	0.082	0.084	7.3	0.085	0.117
1975	0.007	0.124	0.419	0.198	0.025	0.475	0.366	0.191	0.034	0.134	11.4	0.195	0.182
1976	0.009	0.067	0.100	0.422	0.182	0.000	0.511	0.000	0.025	0.291	23.0	0.348	0.170
1977	0.002	0.225	0.036	0.145	0.264	0.344	0.001	0.973	0.025	0.195	16.1	0.225	0.279
1978	0.002	0.075	0.490	0.123	0.199	0.469	0.294	0.109	0.020	0.210	17.2	0.234	0.309
1979	0.006	0.007	0.066	0.391	0.422	0.367	0.722	0.251	0.032	0.389	29.4	0.399	0.446
1980	0.007	0.609	0.146	0.126	0.390	0.408	0.424	0.367	0.027	0.318	24.8	0.331	0.392
1981	0.014	0.156	0.491	0.252	0.315	0.355	0.473	0.182	0.016	0.307	24.1	0.324	0.344
1982	0.003	0.226	0.366	0.398	0.204	0.422	0.373	0.493	0.132	0.371	28.3	0.380	0.348
1983	0.007	0.125	0.323	0.333	0.418	0.322	0.198	0.361	0.080	0.357	27.4	0.371	0.381
1984	0.007	0.053	0.318	0.277	0.262	0.565	0.525	0.533	0.338	0.418	31.2	0.433	0.482
1985	0.008	0.221	0.305	0.390	0.249	0.192	0.373	0.282	0.151	0.275	21.9	0.303	0.287
1986	0.009	0.035	0.427	0.207	0.597	0.240	0.268	0.287	0.060	0.240	19.4	0.283	0.317
1987	0.002	0.233	0.150	0.491	0.181	0.526	0.255	0.258	0.123	0.381	28.9	0.427	0.251
1988	0.005	0.056	0.412	0.207	0.583	0.308	0.795	0.216	0.118	0.383	29.0	0.454	0.515
1989	0.004	0.118	0.122	0.241	0.354	0.443	0.130	1.675	0.058	0.257	20.6	0.288	0.390
1990	0.016	0.014	0.175	0.268	0.402	0.312	0.424	0.267	0.069	0.329	25.6	0.373	0.391
1991	0.014	0.299	0.211	0.454	0.311	0.378	0.633	0.842	0.109	0.428	31.8	0.452	0.445
1992	0.008	0.205	0.345	0.504	0.668	0.552	0.605	0.499	0.191	0.589	40.7	0.637	0.648
1993	0.008	0.051	0.489	0.564	0.777	0.704	0.433	0.653	0.207	0.594	41.0	0.655	0.687
1994	0.004	0.037	0.186	0.417	0.213	1.873	0.298	0.880	0.111	0.343	26.5	0.408	0.404
1995	0.004	0.010	0.086	0.146	0.250	0.137	0.505	0.188	0.057	0.149	12.6	0.156	0.198
1996	0.003	0.011	0.068	0.194	0.217	0.512	0.141	2.039	0.185	0.206	16.9	0.207	0.234
1997	0.004	0.026	0.032	0.101	0.160	0.147	0.189	0.085	0.123	0.125	10.7	0.126	0.155
1998	0.005	0.018	0.095	0.134	0.138	0.218	0.120	0.264	0.128	0.154	13.0	0.155	0.161
1999	0.004	0.010	0.083	0.138	0.176	0.119	0.180	0.141	0.108	0.144	12.2	0.145	0.148
2000	0.003	0.019	0.112	0.189	0.151	0.213	0.099	0.190	0.097	0.167	14.0	0.171	0.150
2001	0.003	0.011	0.128	0.189	0.186	0.233	0.339	0.149	0.173	0.194	16.0	0.196	0.198
2002	0.003	0.008	0.044	0.200	0.198	0.220	0.147	0.303	0.149	0.198	16.3	0.204	0.209
2003	0.005	0.006	0.047	0.071	0.236	0.357	0.241	0.206	0.145	0.197	16.2	0.202	0.251
2004	0.003	0.013	0.031	0.122	0.204	0.397	1.002	0.345	0.181	0.182	15.1	0.182	0.377
2005	0.003	0.003	0.025	0.142	0.349	0.278	0.378	0.692	0.083	0.322	25.1	0.338	0.349
2006	0.002	0.003	0.013	0.048	0.280	0.414	0.197	0.497	0.109	0.356	27.3	0.377	0.395

Table 23. Beginning of year biomass for EGB haddock during 1969-2007 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2007.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	91	100	3716	1298	1779	19744	7577	539	2686	37532	37440	37340
1970	399	335	134	2944	939	1022	11705	4526	1576	23581	23182	22847
1971	52	1426	425	166	2569	586	651	7302	3919	17097	17045	15618
1972	646	191	1084	222	127	1945	172	160	6620	11165	10520	10329
1973	1324	2199	283	903	111	78	1624	51	4161	10733	9409	7210
1974	390	4334	1773	364	317	28	51	1331	2916	11504	11114	6780
1975	375	1409	4545	1971	395	238	20	44	3393	12391	12016	10607
1976	6281	1364	1852	3936	1754	371	140	12	2721	18432	12151	10787
1977	671	22818	1897	2207	2800	1409	352	74	2186	34415	33744	10926
1978	475	2453	27097	2411	2071	2071	948	310	1772	39608	39133	36680
1979	6042	1737	3384	21867	2313	1636	1228	623	1690	40521	34479	32742
1980	765	22010	2567	4172	16049	1462	1075	527	1808	50434	49669	27659
1981	584	2784	17814	2921	3989	10467	922	621	1793	41895	41311	38527
1982	204	2109	3544	14359	2462	2805	6962	508	1943	34895	34691	32582
1983	302	745	2503	3236	10462	1934	1744	4234	1693	26854	26552	25807
1984	1750	1099	978	2387	2517	6640	1329	1264	4121	22084	20334	19235
1985	185	6372	1551	937	1963	1866	3579	694	3121	20267	20082	13710
1986	1837	591	7920	1445	1051	1791	1934	2508	3072	22150	20313	19722
1987	195	5533	741	7266	1340	397	1275	1061	3851	21659	21464	15930
1988	1509	494	6683	1308	3955	872	205	839	3799	19665	18156	17663
1989	50	5992	534	5424	968	2514	591	80	2777	18928	18879	12887
1990	373	343	8501	704	4666	578	1311	554	2388	19417	19044	18701
1991	224	1383	422	9553	632	3340	352	874	2226	19007	18783	17400
1992	990	911	1371	371	6827	485	2086	166	1977	15184	14194	13283
1993	1415	3163	1238	1282	221	3216	247	943	1393	13118	11703	8540
1994	1380	4418	5353	821	638	140	1761	151	1325	15987	14607	10189
1995	397	5202	7154	5408	607	536	20	1015	1063	21402	21005	15802
1996	796	1857	7854	7363	4751	445	454	11	1752	25283	24487	22630
1997	2196	2376	2374	7877	6258	3529	210	286	1050	26157	23961	21584
1998	767	7251	3874	2797	7596	5130	2991	206	1123	31736	30968	23717
1999	3213	2759	9921	3591	2171	6449	3684	2266	808	34863	31650	28891
2000	1036	10986	4481	12140	3716	2120	5765	2965	2294	45504	44468	33482
2001	6465	3826	16336	4738	10003	3027	1764	4823	4064	55046	48581	44754
2002	338	18750	4604	13311	3500	7429	1973	1009	6137	57051	56713	37963
2003	158	1067	38858	4928	11586	2589	5484	1429	4665	70765	70606	69539
2004	20555	497	1838	41315	4617	7903	1464	3125	3890	85203	64648	64151
2005	218	57199	638	1300	31897	3117	4274	434	5196	104274	104056	46858
2006	1790	1092	83420	679	1154	20524	2327	2727	4035	117749	115959	114867
2007	665	6120	2108	122885	800	1432	12685	1644	3787	152125	151461	145340

Table 24. Partial recruitment of haddock normalized to ages 4 to 8 from the EGB Canadian commercial fishery during 1990-2006.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1990	0.043	0.039	0.470	0.718	1.079	0.836	1.138	0.717	0.186
1991	0.032	0.661	0.467	1.005	0.687	0.836	1.399	1.864	0.242
1992	0.013	0.321	0.542	0.791	1.048	0.866	0.949	0.783	0.300
1993	0.013	0.078	0.747	0.861	1.186	1.075	0.661	0.998	0.316
1994	0.010	0.091	0.456	1.021	0.522	4.587	0.730	2.156	0.272
1995	0.026	0.064	0.555	0.934	1.605	0.881	3.237	1.209	0.367
1996	0.014	0.055	0.330	0.937	1.046	2.469	0.682	9.838	0.894
1997	0.035	0.209	0.256	0.801	1.271	1.170	1.509	0.679	0.982
1998	0.032	0.116	0.617	0.864	0.893	1.407	0.772	1.707	0.828
1999	0.025	0.066	0.569	0.951	1.213	0.820	1.240	0.969	0.744
2000	0.017	0.108	0.657	1.105	0.885	1.243	0.580	1.110	0.569
2001	0.013	0.057	0.656	0.963	0.951	1.189	1.732	0.763	0.883
2002	0.013	0.039	0.216	0.982	0.971	1.082	0.721	1.489	0.730
2003	0.026	0.028	0.231	0.353	1.167	1.763	1.191	1.020	0.716
2004	0.015	0.071	0.171	0.668	1.121	2.180	5.503	1.894	0.992
2005	0.009	0.007	0.075	0.422	1.034	0.824	1.121	2.050	0.244
2006	0.006	0.009	0.035	0.126	0.742	1.096	0.521	1.317	0.289
Avg 1999-02	0.017	0.068	0.524	1.000	1.005	1.084	1.069	1.083	0.731
Avg 2003-05	0.017	0.036	0.159	0.481	1.107	1.589	2.605	1.654	0.651
Avg 2004-06	0.010	0.029	0.094	0.405	0.966	1.367	2.382	1.753	0.509

Table 25. Partial recruitment of haddock normalized to ages 5 to 8 from the EGB Canadian commercial fishery during 1990-2006.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1990	0.041	0.037	0.449	0.685	1.029	0.798	1.086	0.684	0.178
1991	0.032	0.671	0.474	1.021	0.698	0.849	1.421	1.892	0.245
1992	0.013	0.316	0.533	0.778	1.031	0.851	0.933	0.770	0.295
1993	0.012	0.075	0.712	0.821	1.130	1.024	0.630	0.951	0.301
1994	0.011	0.092	0.461	1.031	0.528	4.635	0.738	2.178	0.274
1995	0.020	0.050	0.436	0.735	1.262	0.693	2.545	0.950	0.289
1996	0.013	0.049	0.293	0.831	0.928	2.191	0.605	8.732	0.793
1997	0.028	0.169	0.208	0.649	1.030	0.949	1.224	0.550	0.796
1998	0.031	0.112	0.595	0.832	0.860	1.355	0.744	1.645	0.798
1999	0.024	0.065	0.559	0.935	1.192	0.806	1.219	0.952	0.731
2000	0.020	0.124	0.752	1.265	1.012	1.422	0.664	1.270	0.651
2001	0.013	0.056	0.647	0.951	0.939	1.174	1.710	0.753	0.872
2002	0.013	0.038	0.210	0.954	0.944	1.052	0.701	1.447	0.709
2003	0.021	0.023	0.186	0.285	0.942	1.423	0.961	0.823	0.577
2004	0.007	0.034	0.082	0.323	0.541	1.052	2.657	0.914	0.479
2005	0.009	0.007	0.073	0.408	0.999	0.797	1.084	1.982	0.236
2006	0.006	0.009	0.034	0.121	0.709	1.048	0.498	1.258	0.276
Avg 1999-02	0.018	0.071	0.542	1.026	1.022	1.113	1.073	1.106	0.741
Avg 2003-05	0.012	0.021	0.114	0.338	0.827	1.091	1.567	1.240	0.431
Avg 2004-06	0.007	0.017	0.063	0.284	0.750	0.966	1.413	1.385	0.331

Table 26. Lengths estimated for the EGB haddock 2003 year class based on growth rates from the 1998, 1999 and 2000 year classes for input into the risk assessment for 2008.

Age	Beginning year length (cm)	Growth rate	Calculated length for following year[2]
4	41.0[1]	0.120	46.2
5	46.2	0.074	49.7
6	49.7	-	-

[1]Observed 2007 beginning year length for 2003 year class from DFO survey
[2] $length_{a+1} = length_a \times e^{growth\ rate}$

Table 27. Lengths and weights for EGB haddock from the 2007 DFO survey compared to weights estimated by the relationship between length and weight derived by Waiwood and Nielson (1985).

Age	2007 Survey Lengths	Observed (kg)	LW equation (kg)	% difference
1	20.6	0.077	0.107	72
2	29.6	0.246	0.308	80
3	34.2	0.405	0.471	86
4	41.0	0.709	0.799	89
5	46.7	0.992	1.169	85
6	55.0	1.745	1.877	93
7	53.5	1.559	1.729	90
8	54.1	1.671	1.794	93

Table 28. Beginning year and fishery lengths and weights estimated for the EGB haddock 2003 year class for input into the risk assessment for 2008.

Age	Beginning of year			Fishery	
	Length	Weight[2]	- 10%[3]	Length	Weight[2]
4	41.0[1]	0.709[1]	N/A	48.0[5]	1.263
5	46.2[4]	1.130	1.017	51.0[5]	1.507
6	49.7[4]	1.400	1.260		

[1]Observed 2007 beginning year length or weight for 2003 year class from DFO survey
[2] $weight = 0.0000158 \times length^{2.91612}$ *(Waiwood and Neilson 1985)*
[3]Weight reduced by 10% to reflect lower values for survey weights versus fishery weights
[4]Calculated length
[5]Estimated from relationship between beginning of year (DFO survey) and fishery lengths the same year.

Table 29. Input for projections and risk analyses of EGB haddock for the 2008 fishery. A catch of 19,000 mt in 2007 and M = 0.2 were assumed for the forecasts.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2007	8147	24459	4859	169942	761	733	9336	876	1552
Partial Recruitment to the Fishery[1]									
2007	0.01	0.02	0.05	0.2	0.6	1	1	1	1
2008	0.01	0.02	0.05	0.2	0.52	1	1	1	1
Weight at beginning of year for population (kg)[3]									
2007	0.08	0.25	0.41	0.71	0.99	1.75	1.56	1.67	1.86
2008	0.08	0.25	0.41	0.71	1.02[4]	1.75	1.56	1.67	1.86
2009	0.08	0.25	0.41	0.71	1.02[4]	1.26[4]	1.56	1.67	1.86
Weight at age for catch (kg)[5]									
2008	0.34	0.51	0.98	1.26[6]	1.60	1.78	1.87	2.02	2.21
2009	0.34	0.51	0.98	1.26[6]	1.51[6]	1.78	1.87	2.02	2.21
Maturity									
2005	0	0	1	1	1	1	1	1	1
2006	0	0	1	1	1	1	1	1	1
2007	0	0	1	1	1	1	1	1	1

[1]Estimated from observed 2005 partial recruitment except where indicated.
[2]Derived from relationship between 2003 to 2005 survey lengths at age and partial recruitment values.
[3]Equal to 2006 DFO survey weights except where indicated.
[4]Estimated weights based on a growth model for the 2003 year class and reduced by 10% to reflect lower condition (see Table 28).
[5]Equal to 2006 Canadian fishery weights except where indicated.
[6]Estimated weights based on a growth model for the 2003 year class.

Table 30. Bias adjusted deterministic projection results for EGB haddock for the 2008 fishery using 20 million recruits for the 2007 and 2008 year classes and assuming that the 2007 quota of 19,000 mt is caught.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2007	8682	24929	5207	173311	807	820	8134	984	2034			
2008	20000	7085	20276	4193	132829	542	483	4787	1776			
2009	20000	16332	5770	16386	3259	94999	342	305	4143			
Population Biomass (mt)												
2007	665	6120	2108	122885	800	1432	12685	1644	3787	152125	151461	145340
2008	1540	1743	8212	2973	135087	946	753	7999	3307	162560	161020	159277
2009	1540	4018	2337	11618	3315	119698	533	509	7715	151283	149743	145725
Fishing mortality												
2007	0.00	0.01	0.02	0.07	0.20	0.33	0.33	0.33	0.33			
2008	0.00	0.01	0.01	0.05	0.14	0.26	0.26	0.26	0.26			
Projected Catch Numbers (000s)												
2007	26	149	77	10048	132	210	2084	252	521			
2008	47	33	237	193	15259	113	101	998	370			
Catch Biomass (mt)												
2007	9	76	76	12690	211	375	3902	509	1152	19000		
2008	16	17	232	243	22995	201	188	2014	818	26725		

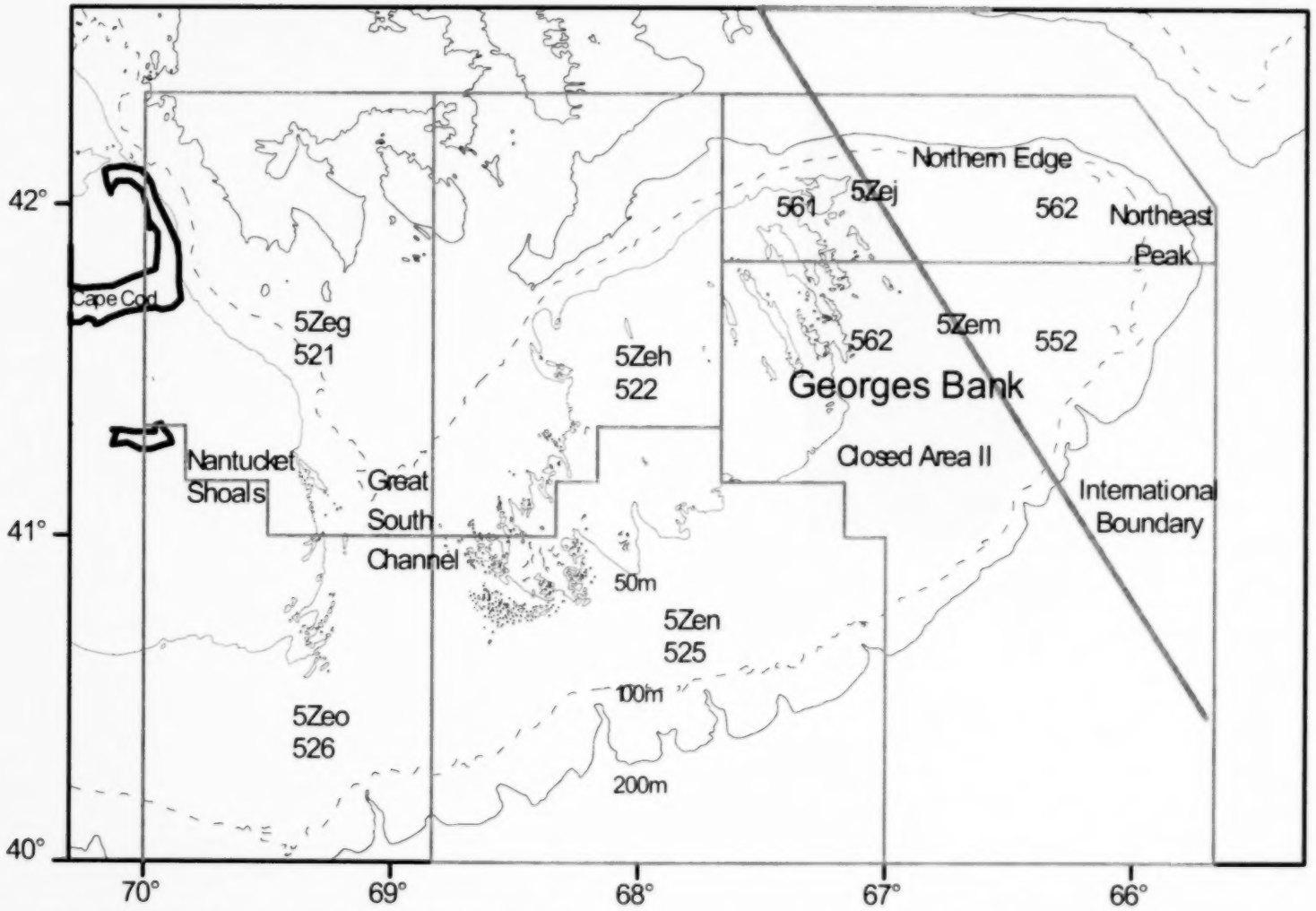

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are DFO designations and numeric codes, e.g. 561, are NMFS designations.

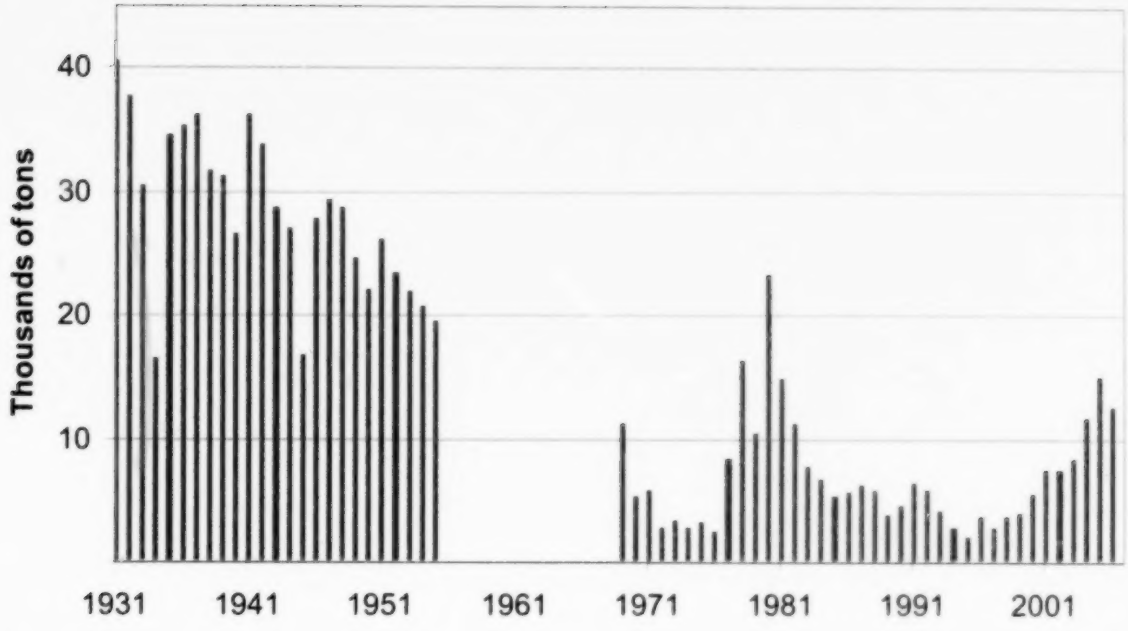

Figure 2. Historical catch of EGB haddock during 1931-1955 compared to recent catches during 1969-2006.

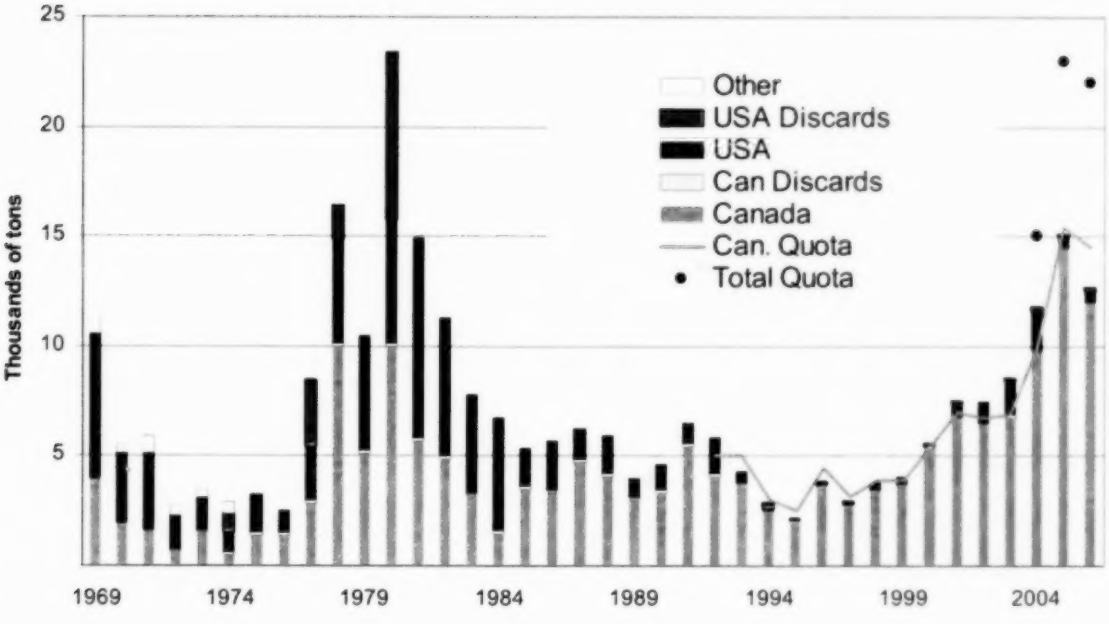

Figure 3. Nominal catch of EGB haddock during 1969-2006.

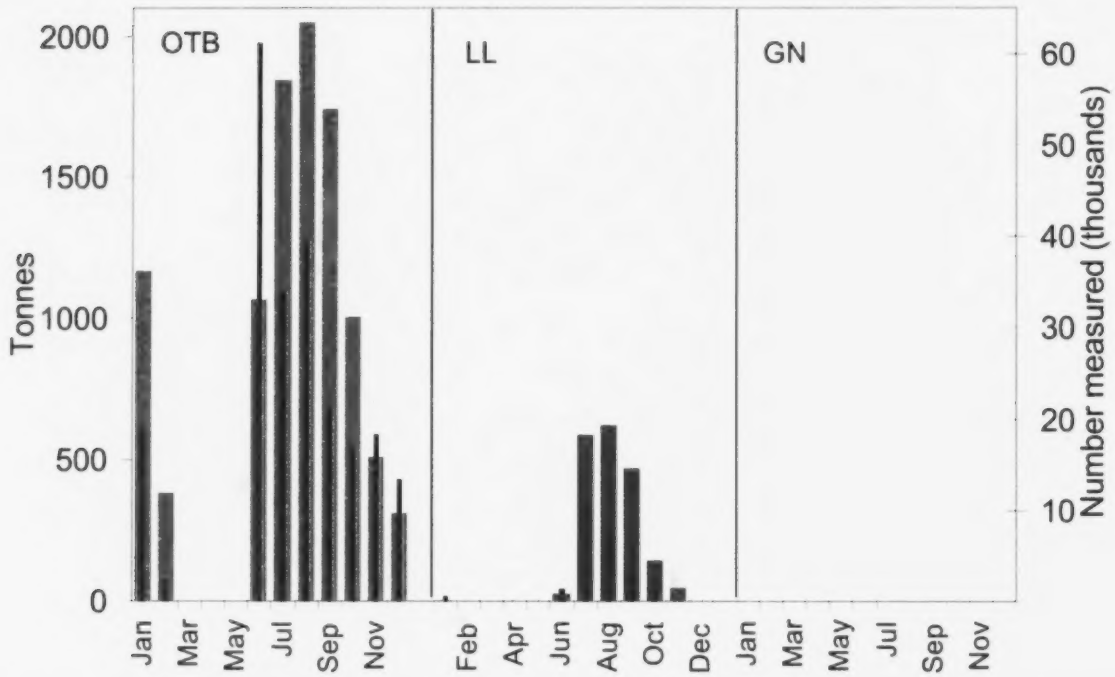

Figure 4. Haddock catches in EGB by month and gear for the Canadian commercial groundfish fishery in 2006 (wide bars) with sampling levels (narrow bars).

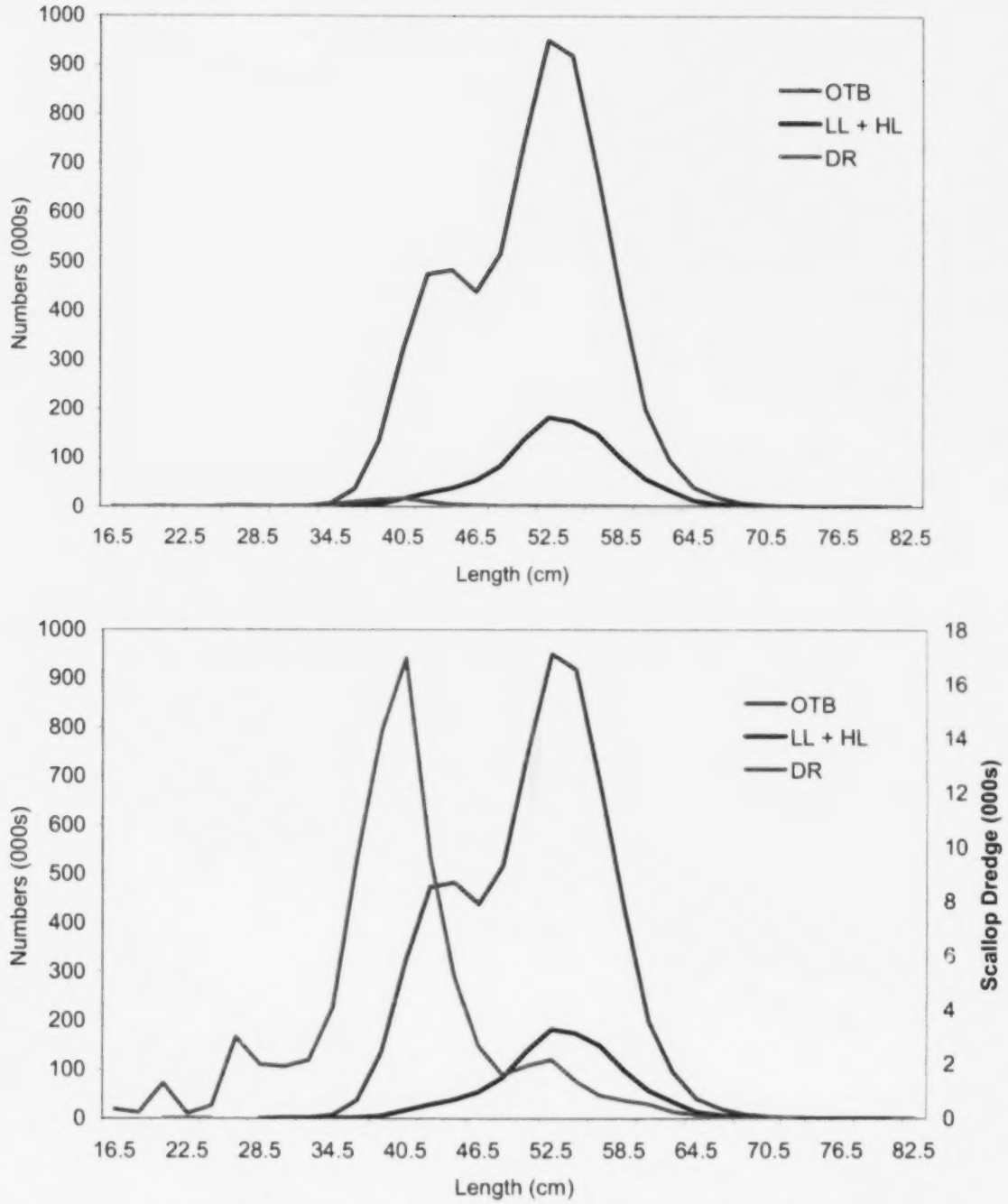

Figure 5. Catch at length by the principal Canadian EGB commercial haddock fisheries in 2006. In the lower graph the scallop dredge length frequency is expanded according to the axis on the right.

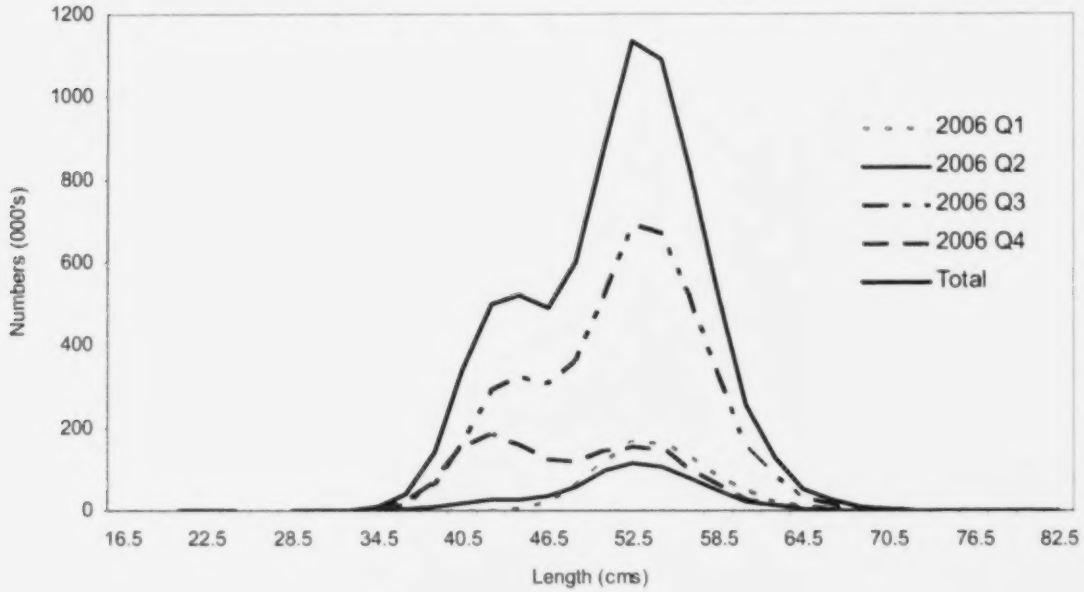

Figure 6. Catch at length by quarter for the Canadian EGB commercial haddock fisheries in 2006.

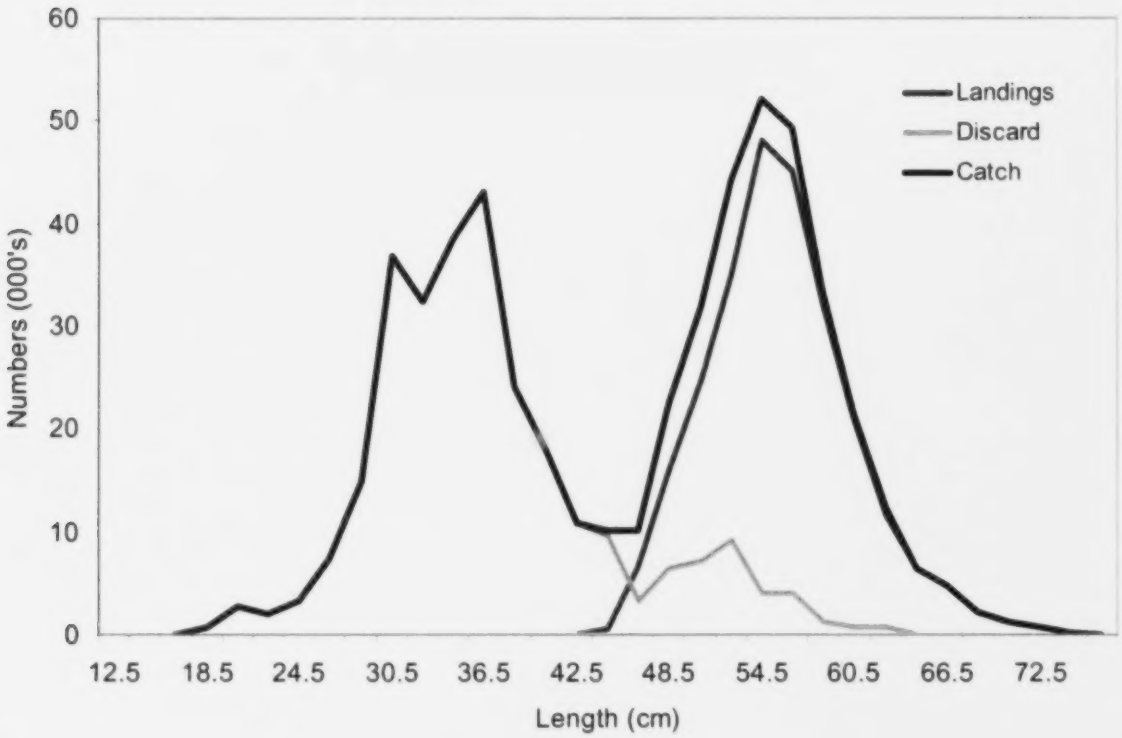

Figure 7. Catch at length of haddock by the USA EGB groundfish fisheries in 2006.

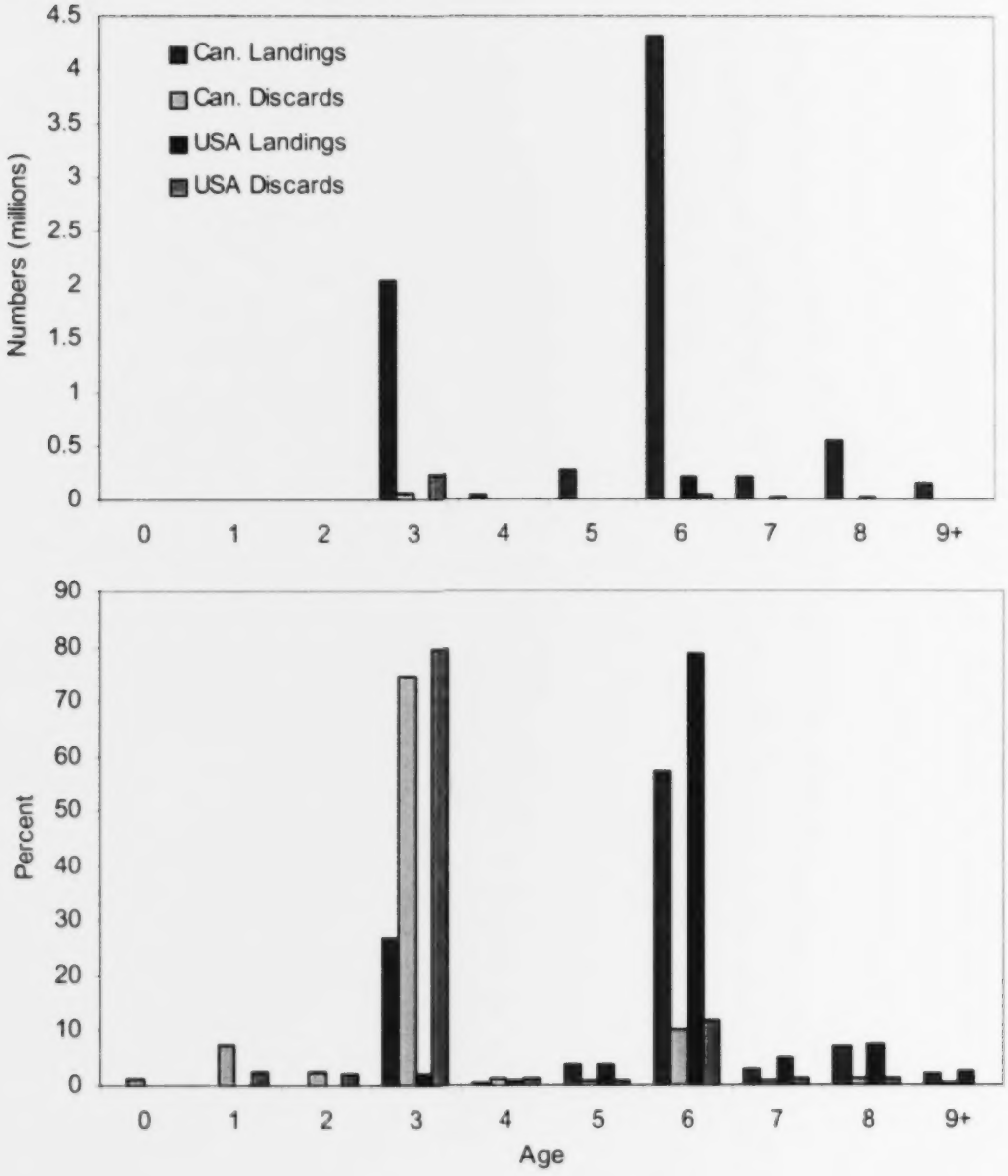

Figure 8. Composition in numbers and percent of the EGB haddock Canadian and USA landings and discards in 2006.

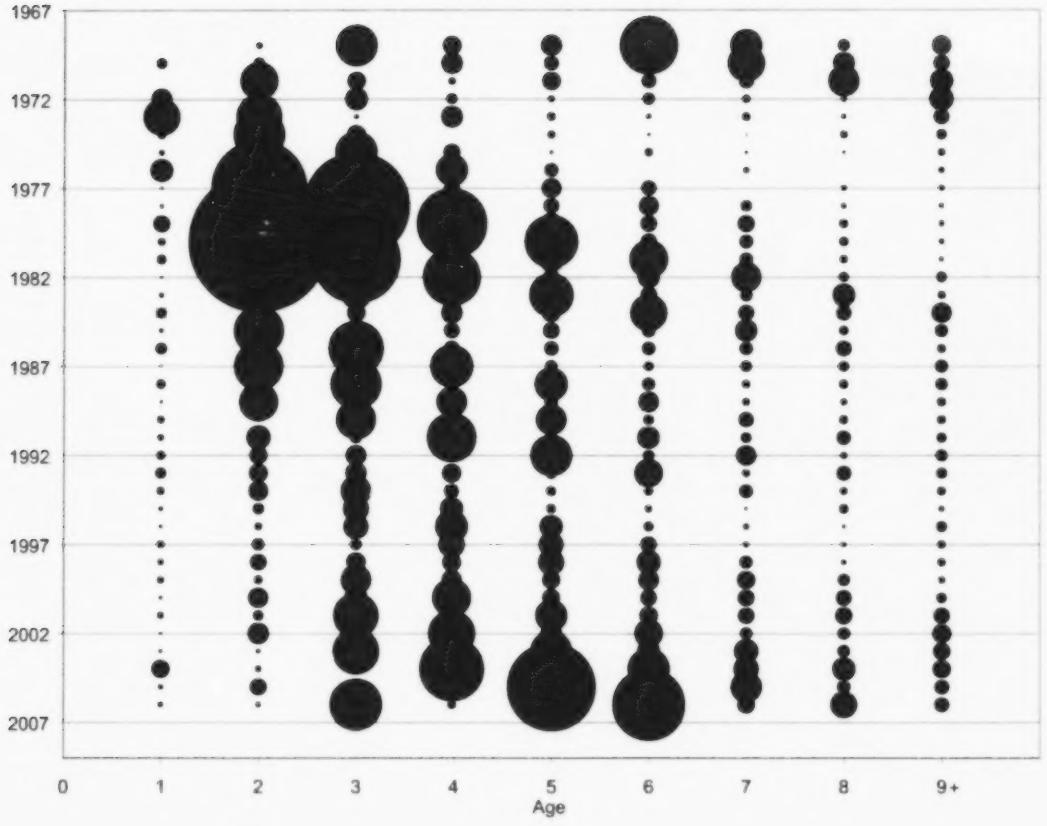

Figure 9. Total commercial catch at age (numbers) of EGB haddock during 1969-2006. The bubble area is proportional to magnitude.

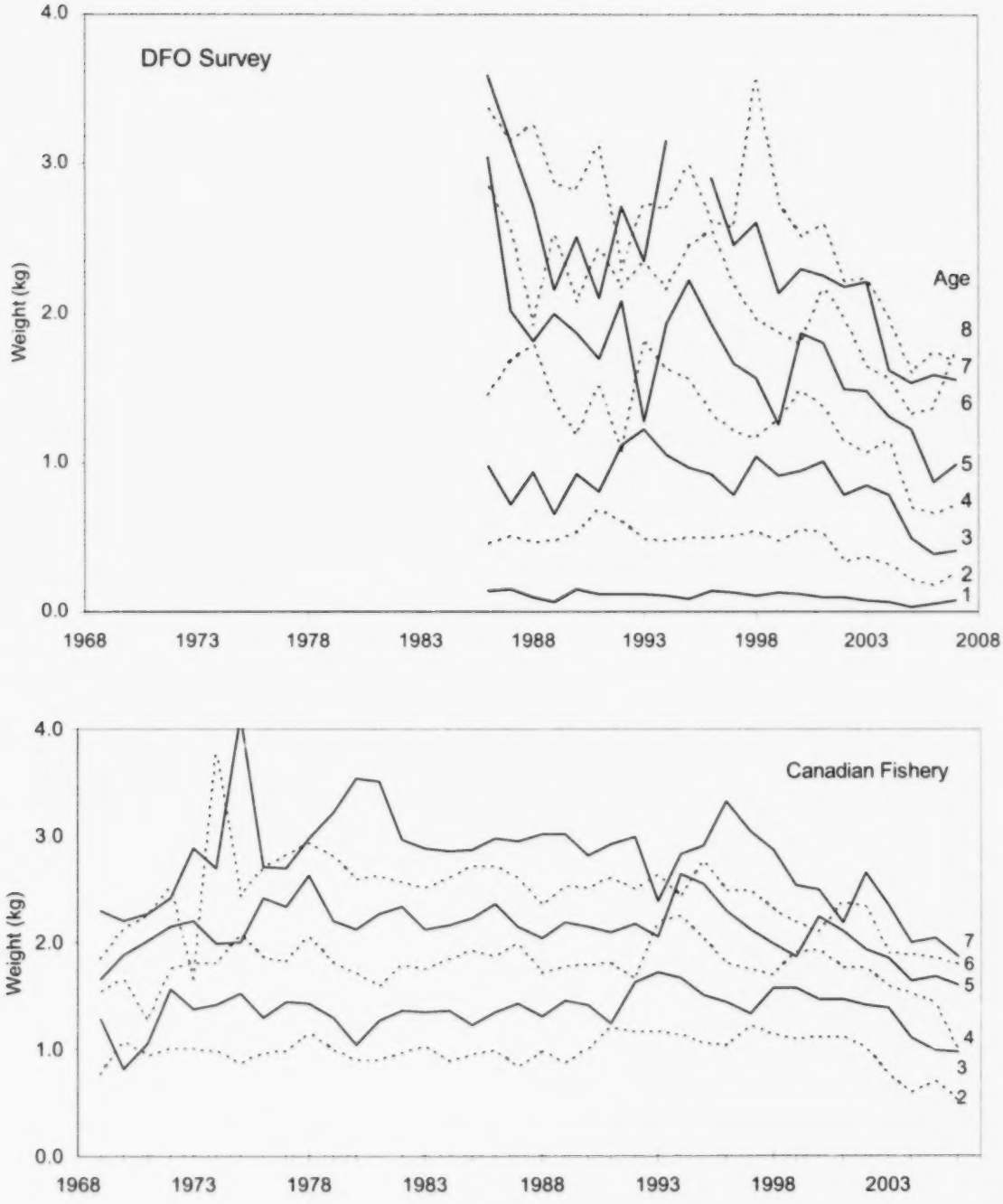

Figure 10. Average weights at age for EGB haddock from the Canadian commercial groundfish fishery during 1969-2006 and from the DFO survey during 1986-2007.

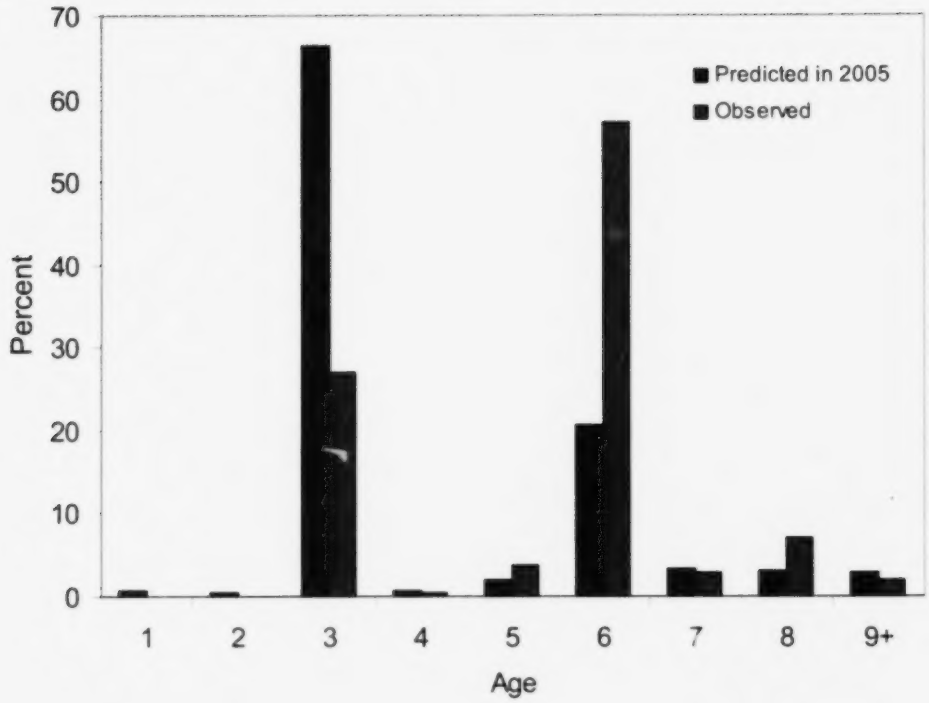

Figure 11. Actual and projected 2006 EGB haddock catch in percent composition

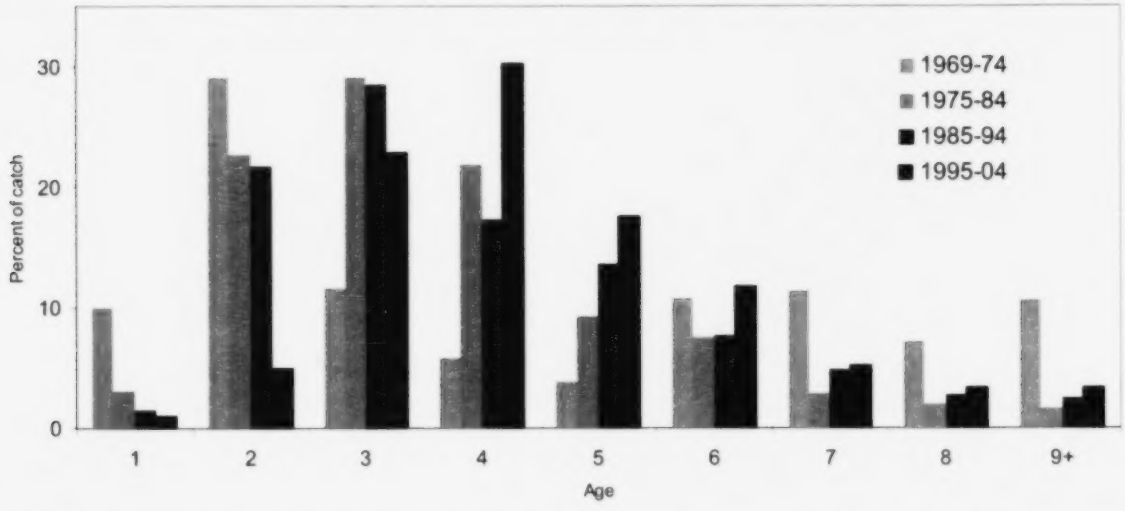

Figure 12. Age composition of the haddock catch for the EGB commercial fishery during 1969-1974, 1975-1984, 1985-1994, and 1995-2004.

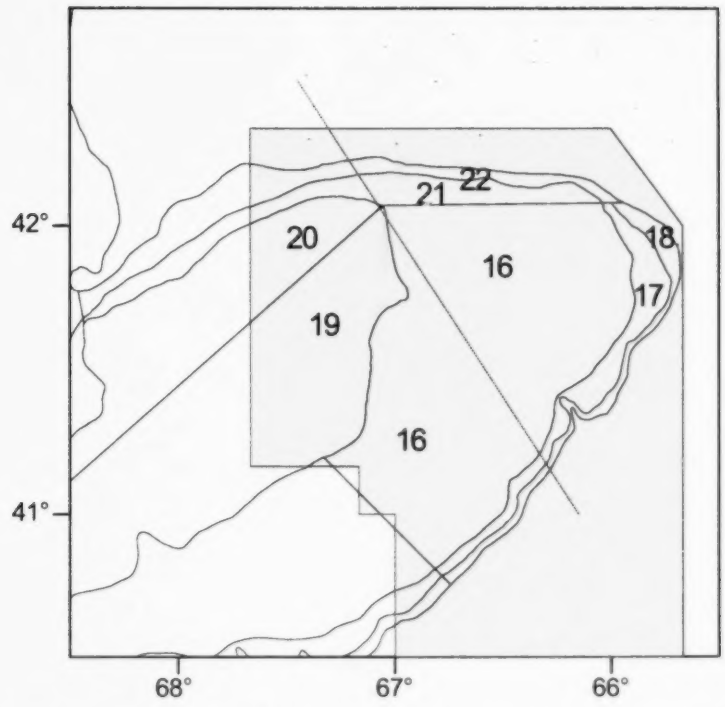

Figure 13. Stratification scheme used for NMFS surveys. The EGB management area is indicated by shading.

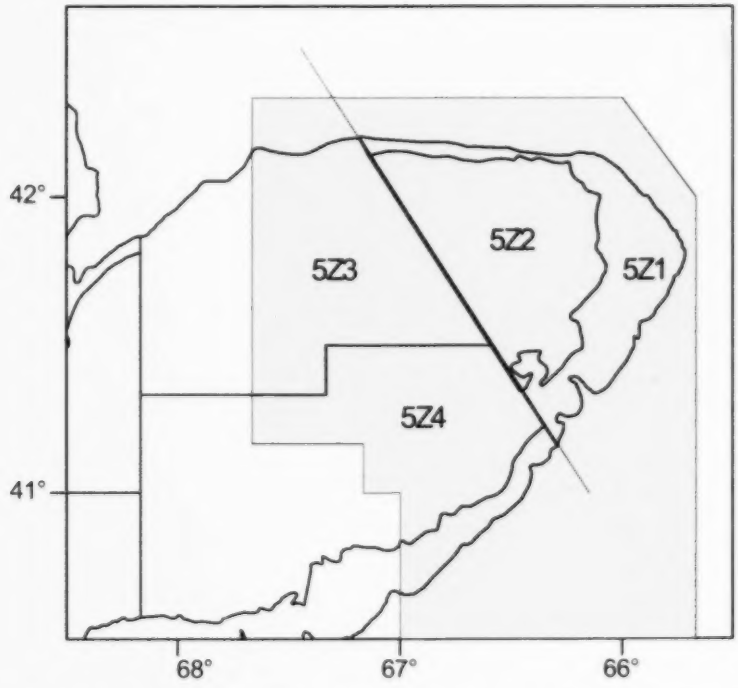

Figure 14. Stratification scheme used for the DFO survey. The EGB management area is indicated by shading.

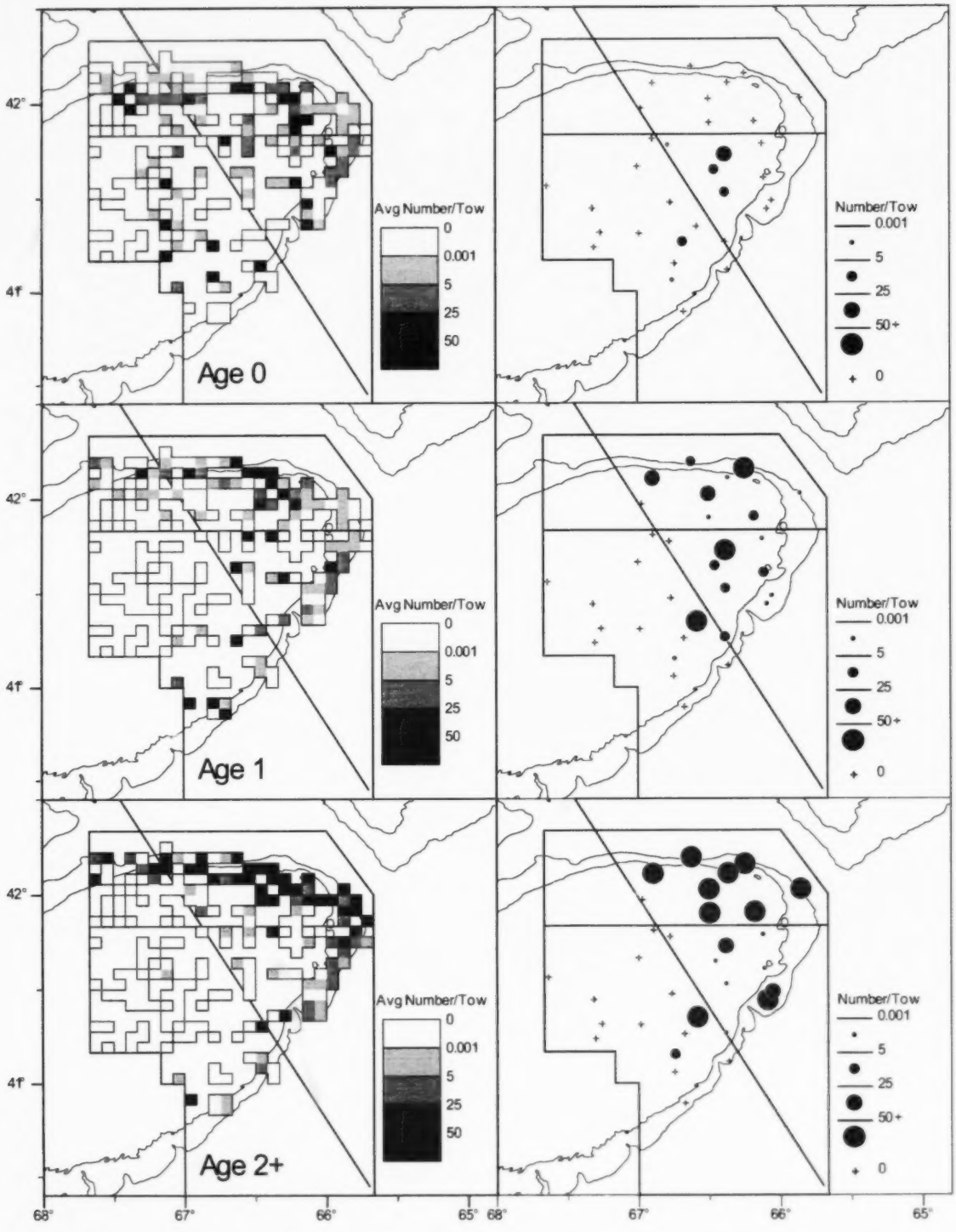

Figure 15. Distribution of EGB haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares (left panels) are shaded relative to the average catch for 1995 to 2005. The expanding symbols (right panels) represent the **2006** survey catches.

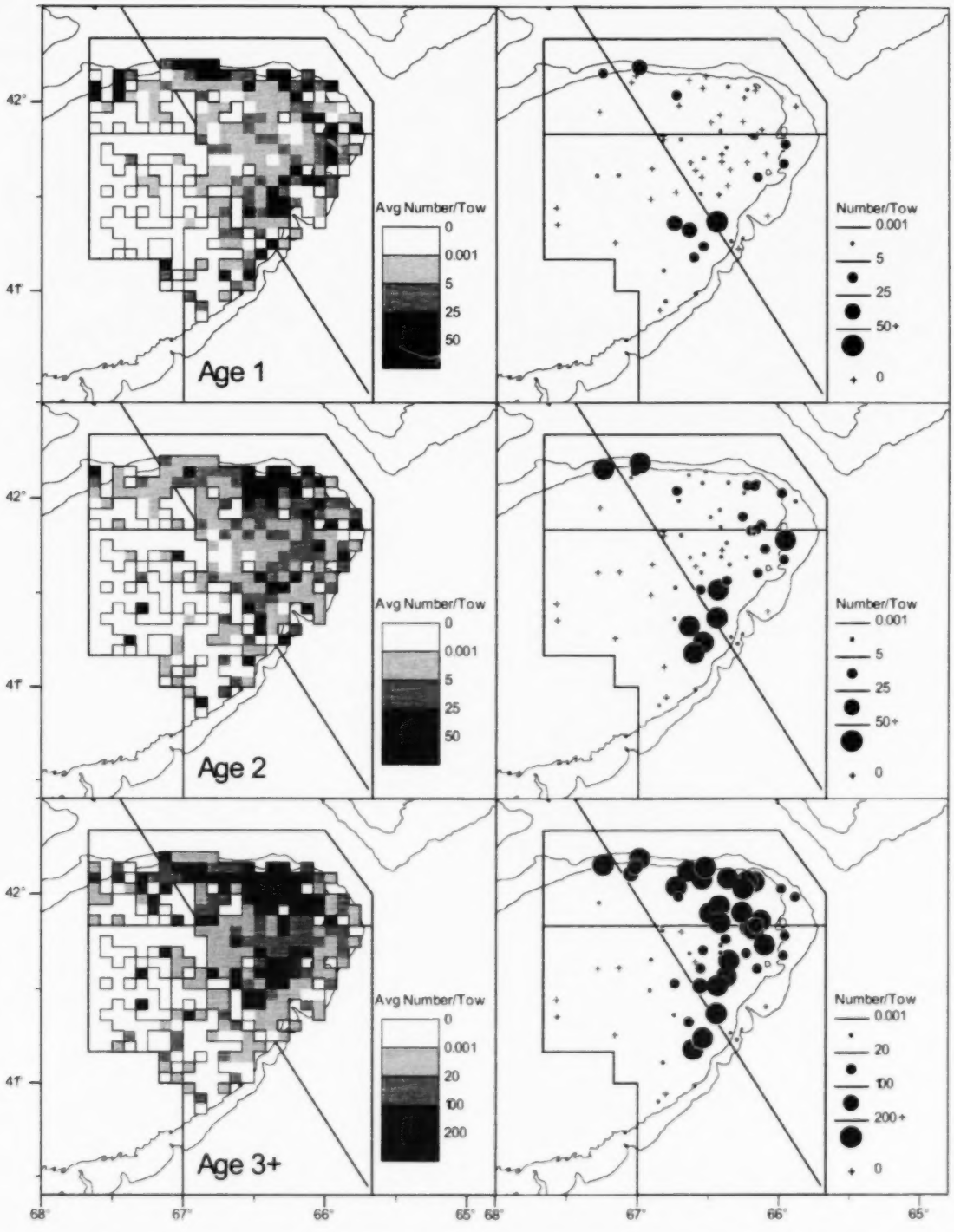

Figure 16. Distribution of EGB haddock abundance (number/tow) as observed from the **DFO** survey. The squares (left panels) are shaded relative to the average catch for 1996 to 2006. The expanding symbols (right panels) represent the **2007** survey catches.

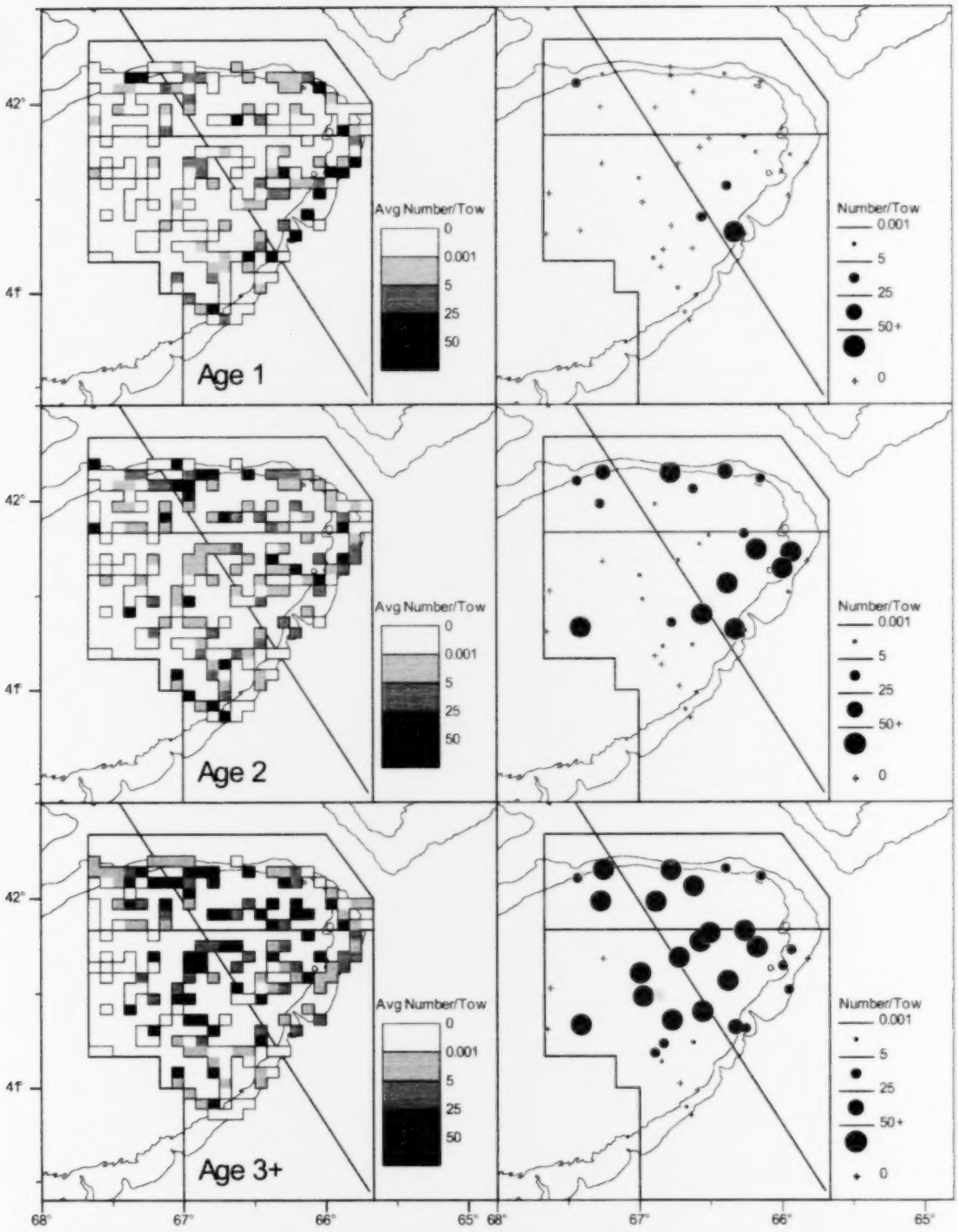

Figure 17. Distribution of EGB haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares (left panels) are shaded relative to the average catch for 1996 to 2006. The expanding symbols (right panels) represent the **2007** survey catches.

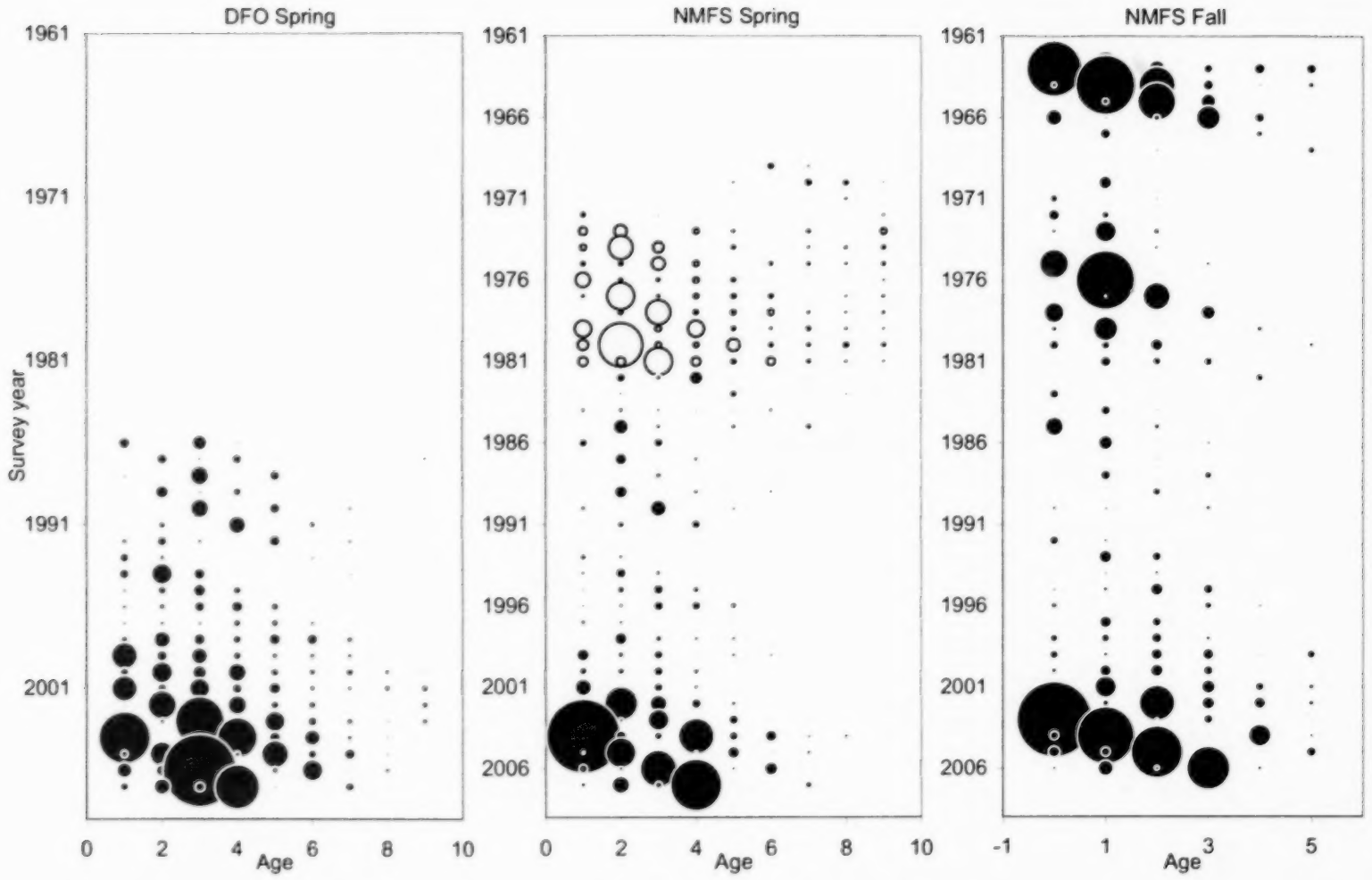

Figure 18. Estimated abundance at age (numbers in 000's) of EGB haddock for the DFO, NMFS spring and NMFS fall surveys during 1963-2007. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

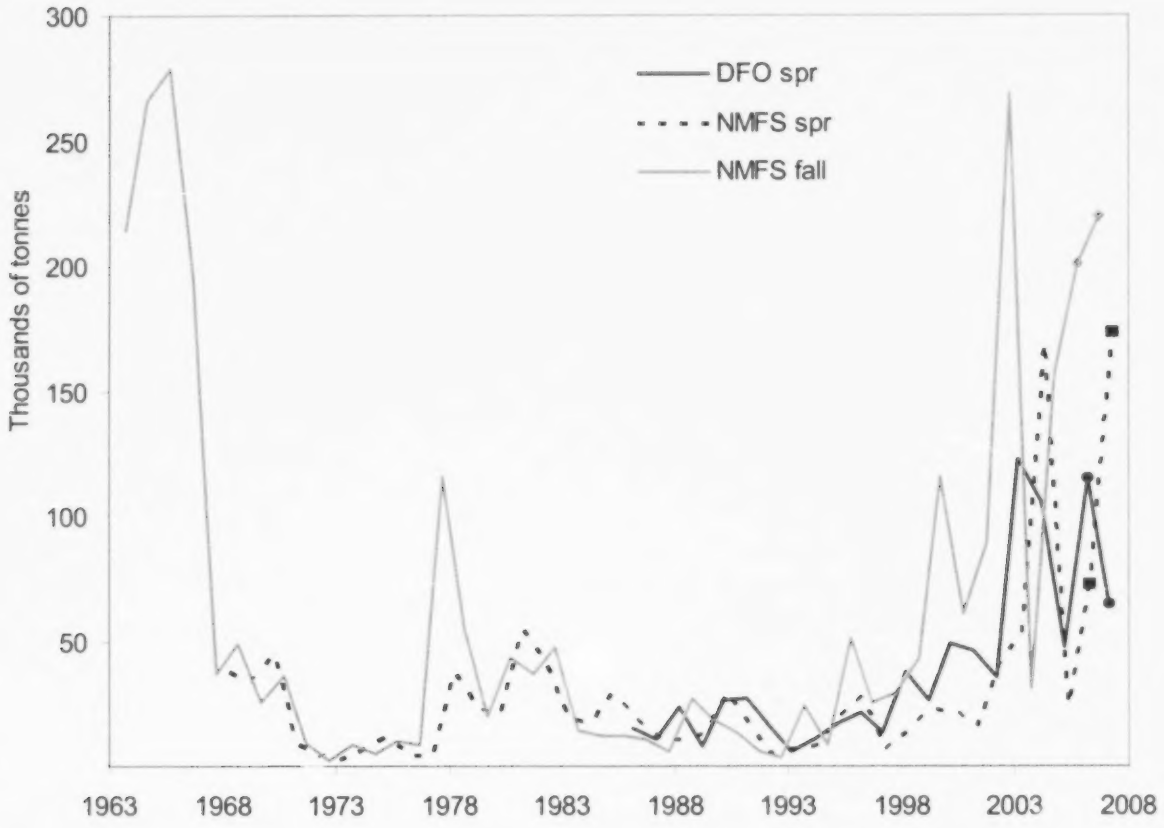

Figure 19. Biomass from NMFS fall (ages 2-8), NMFS spring (ages 3-8) and DFO (ages 3-8) research surveys (scaled by calibration constants) for EGB haddock during 1963-2007.

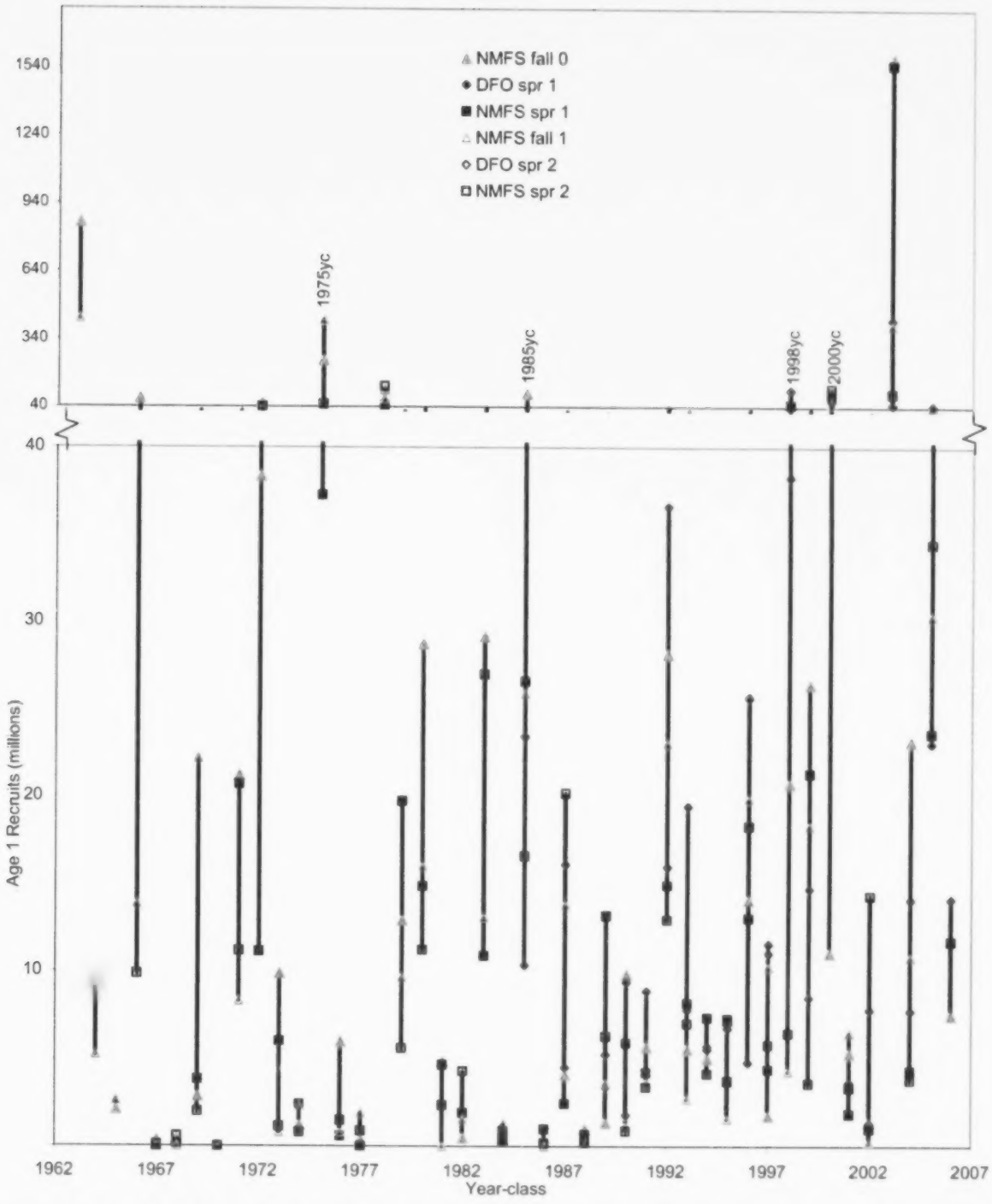

Figure 20. Year-class abundance for ages 0 and 1 from the NMFS fall survey and ages 1 and 2 from the NMFS spring and DFO research surveys (scaled by calibration constants) for EGB haddock during 1963-2007.

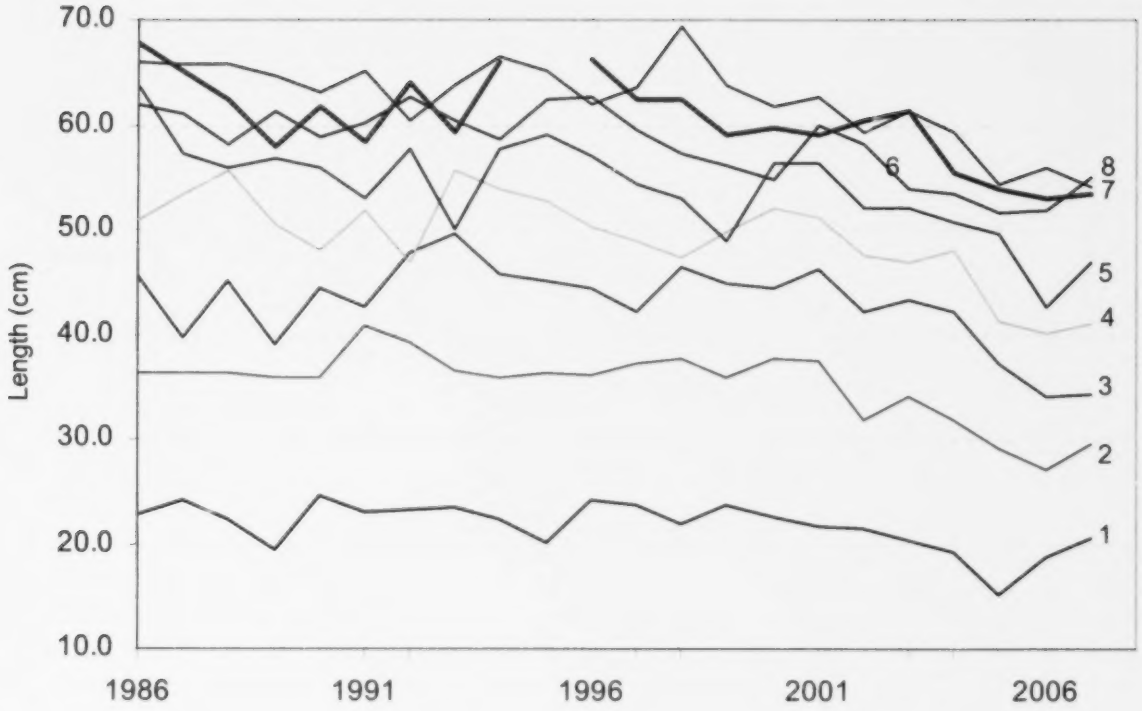

Figure 21. Length at age for EGB haddock derived from DFO surveys during 1986-2007.

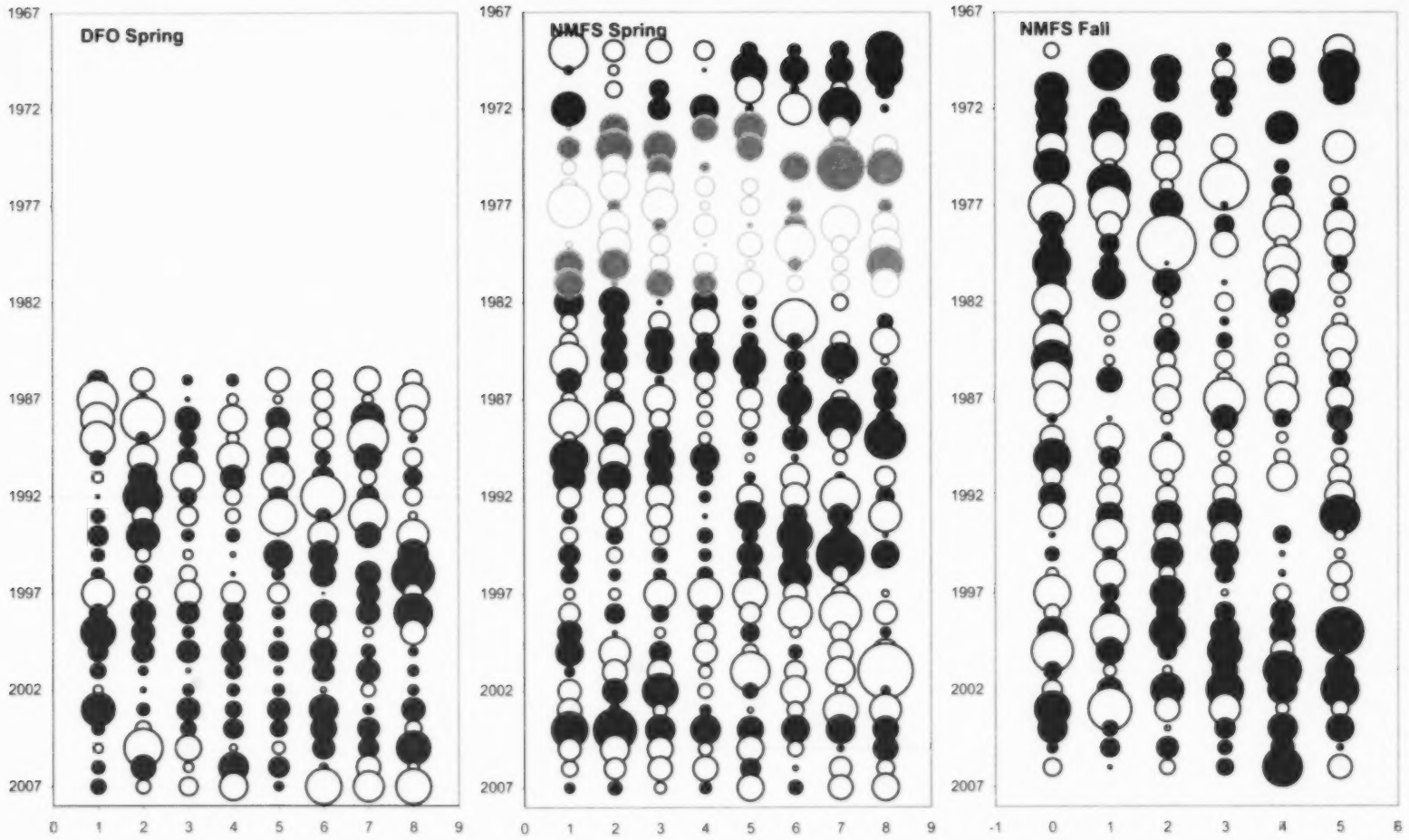

Figure 22. Residuals by year and age group for research survey indices during 1969-2006 for EGB haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

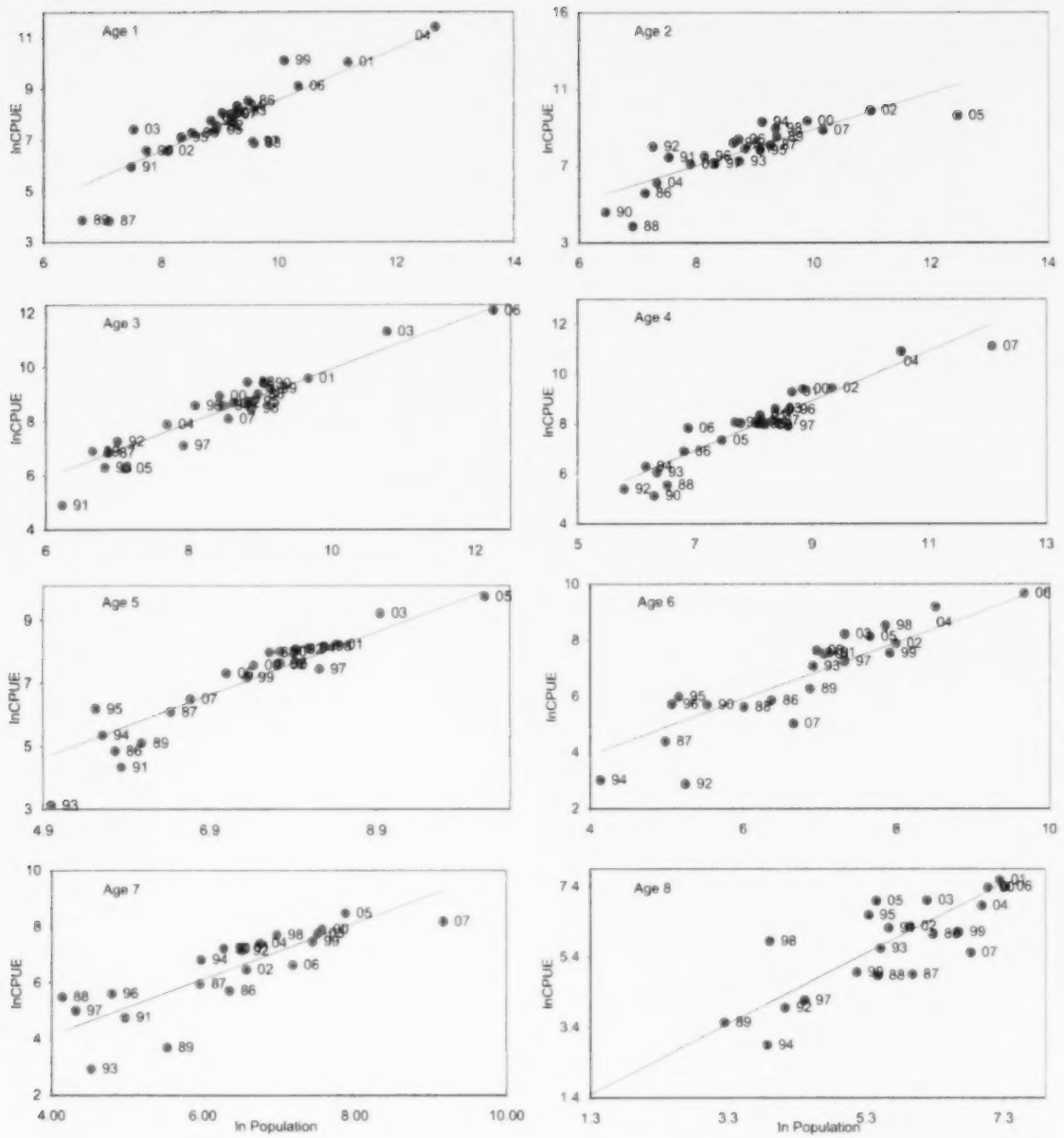

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **DFO** survey during 1986-2007.

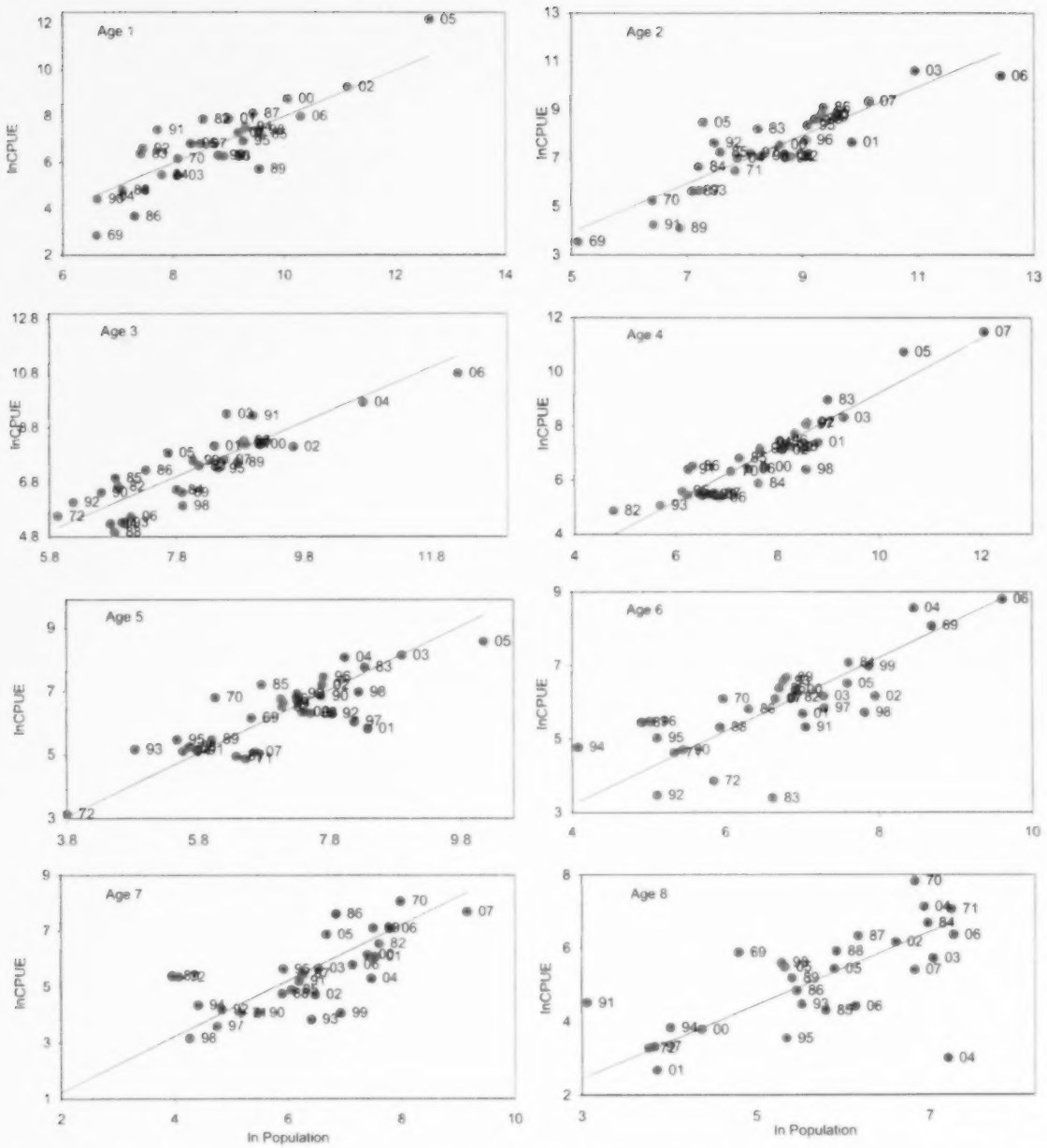

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS spring** survey with a Yankee 36 net during 1969-1972 and 1982-2007.

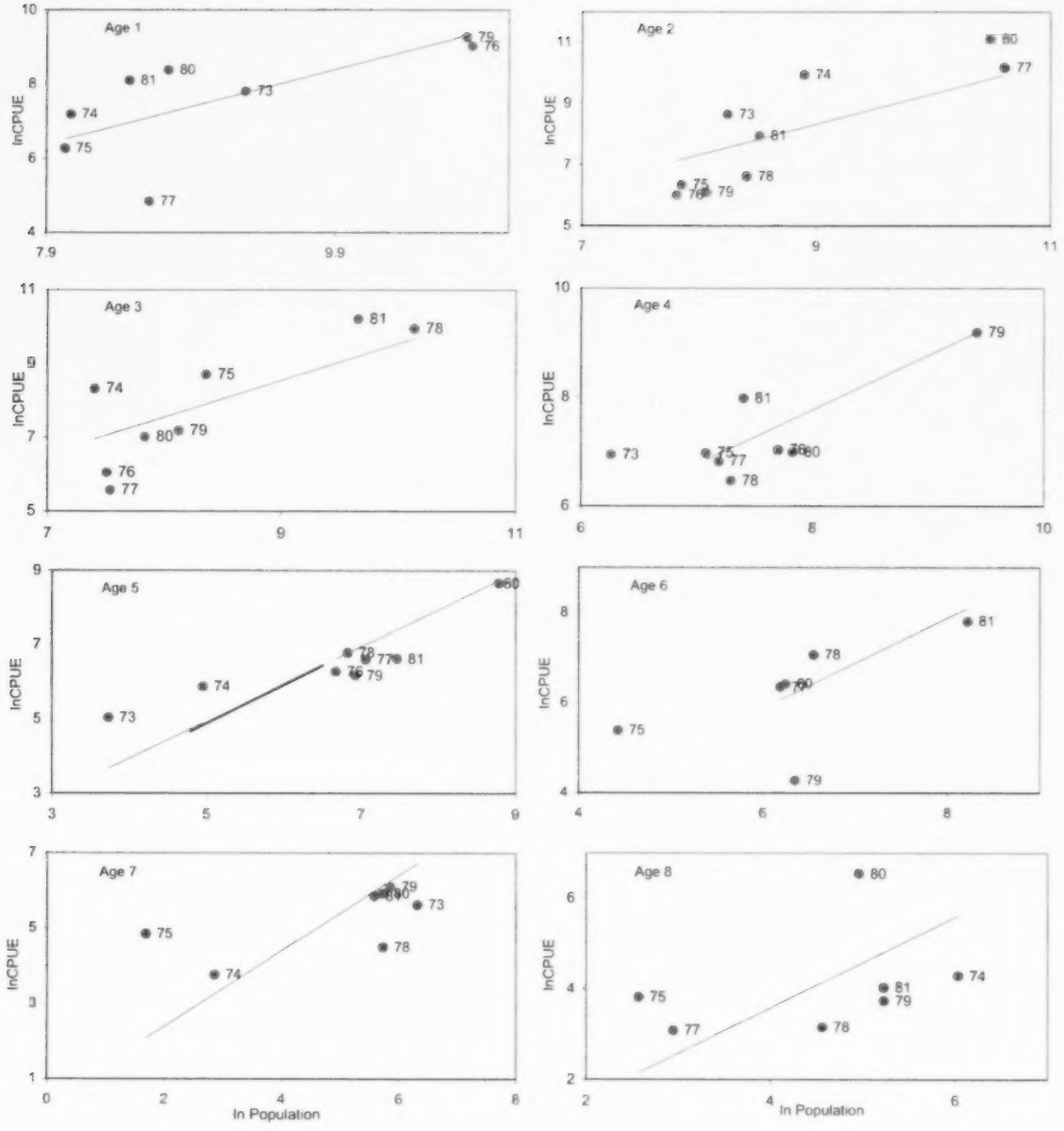

Figure 25. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS spring** survey with a Yankee 41 net during 1973-1981.

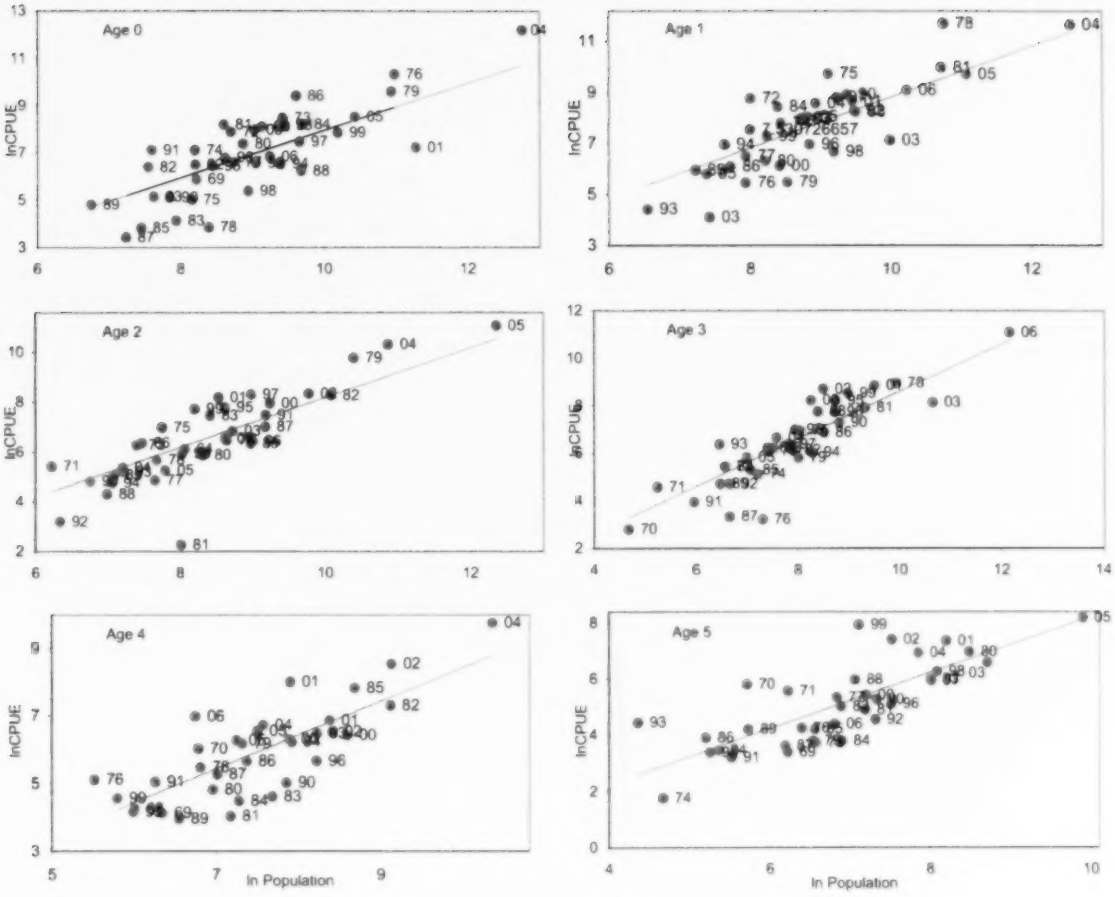

Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS fall** survey 1969-2006.

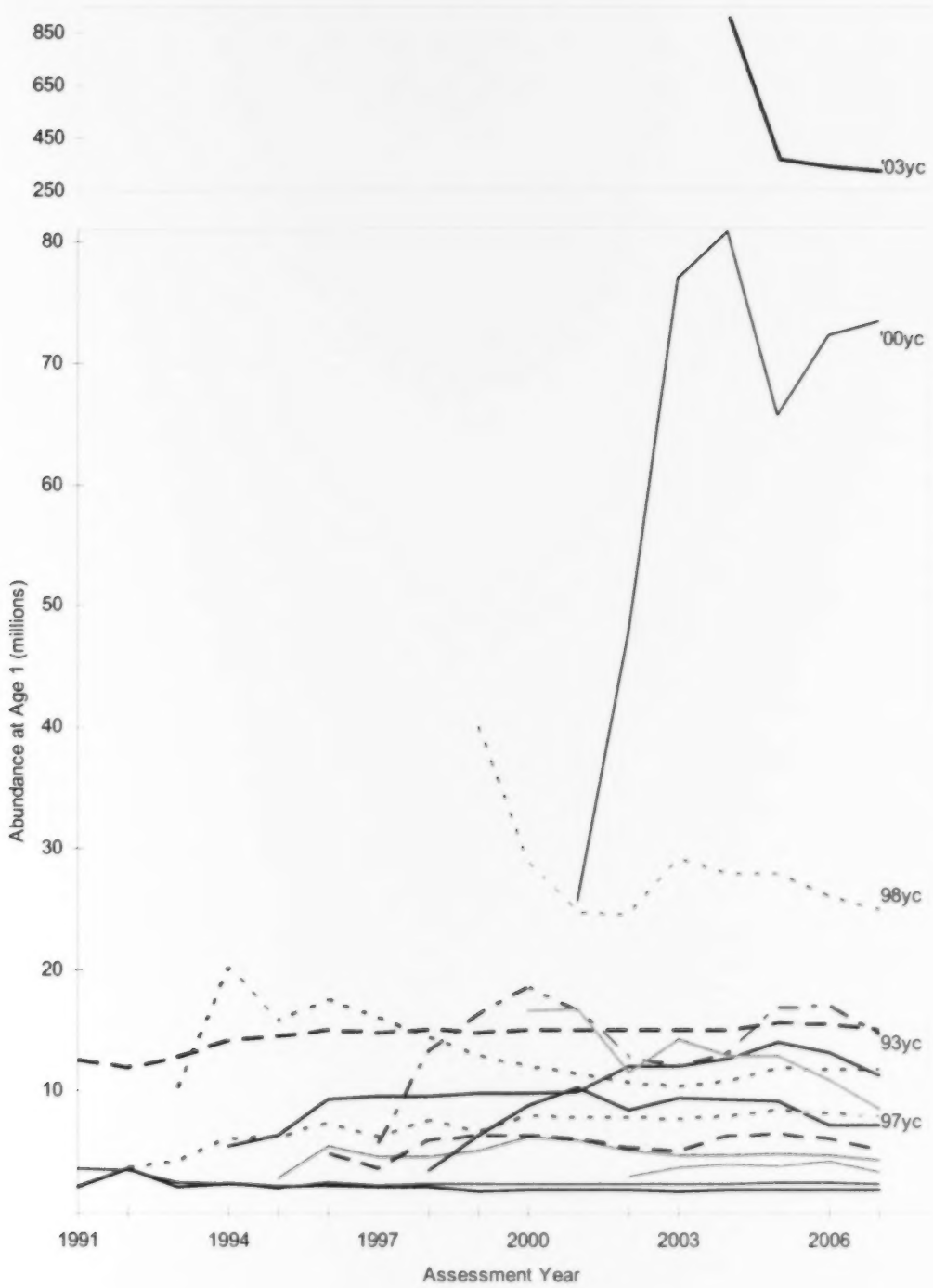

Figure 27. Retrospective estimates of EGB haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

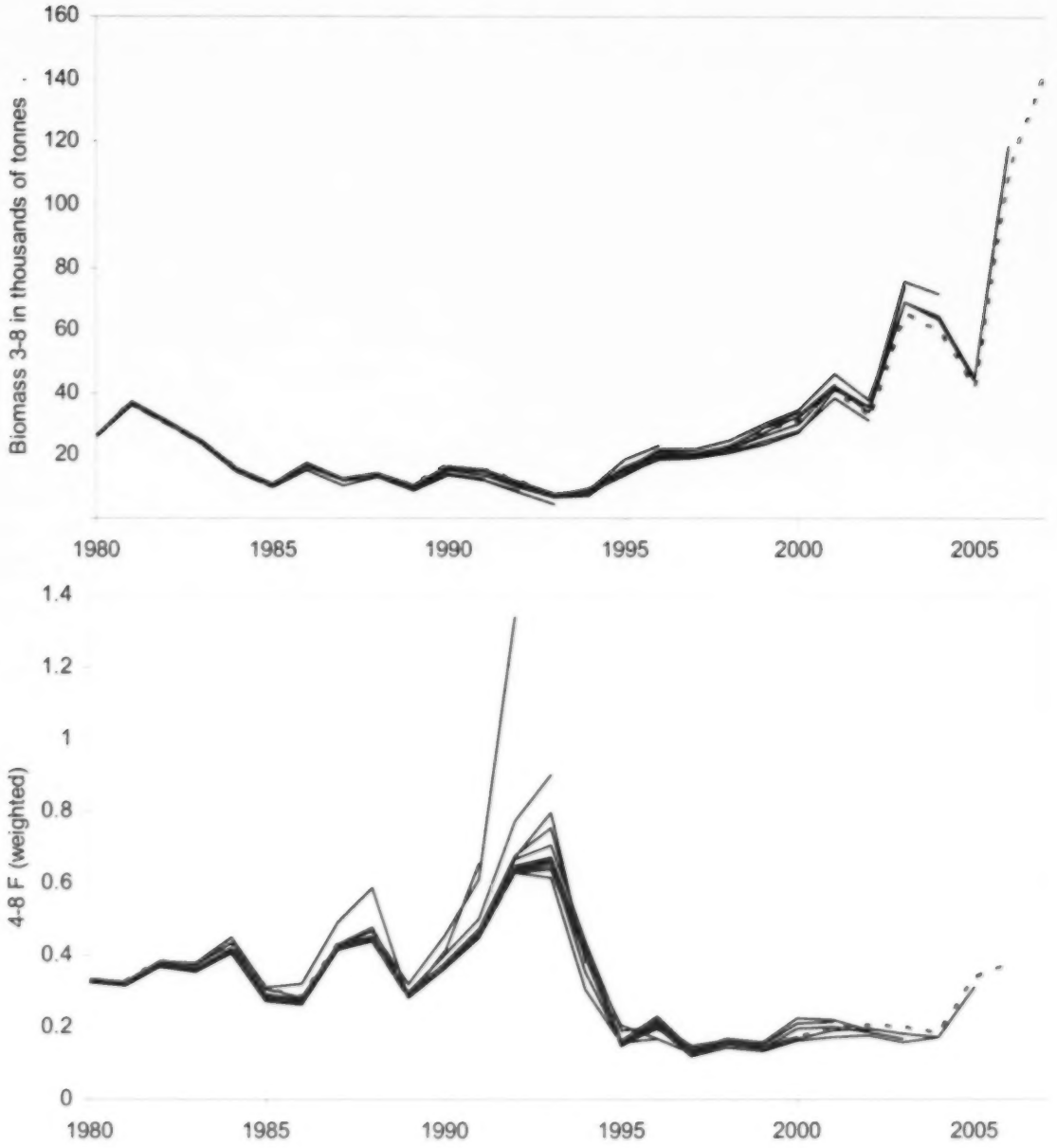

Figure 28. Retrospective estimates from VPA of EGB haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

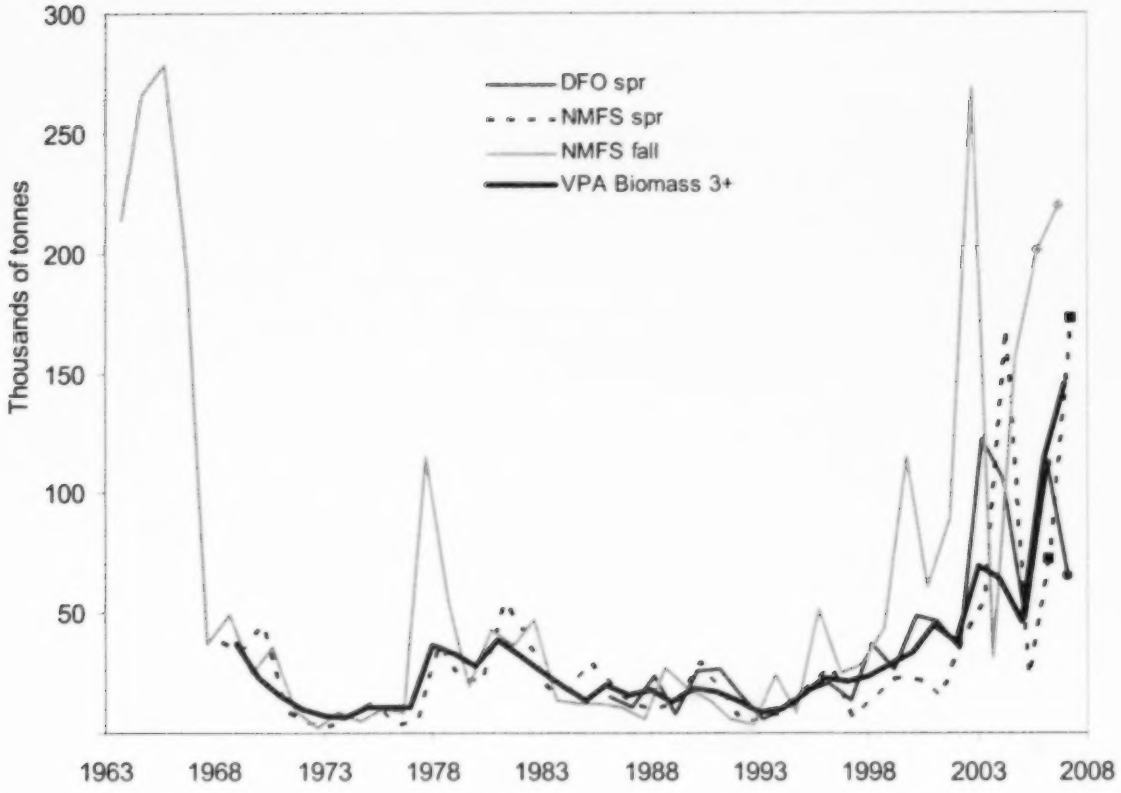

Figure 29. The EGB adult haddock (ages 3+) biomass trend from VPA compared with the survey adult biomass (scaled with catchabilities) trends.

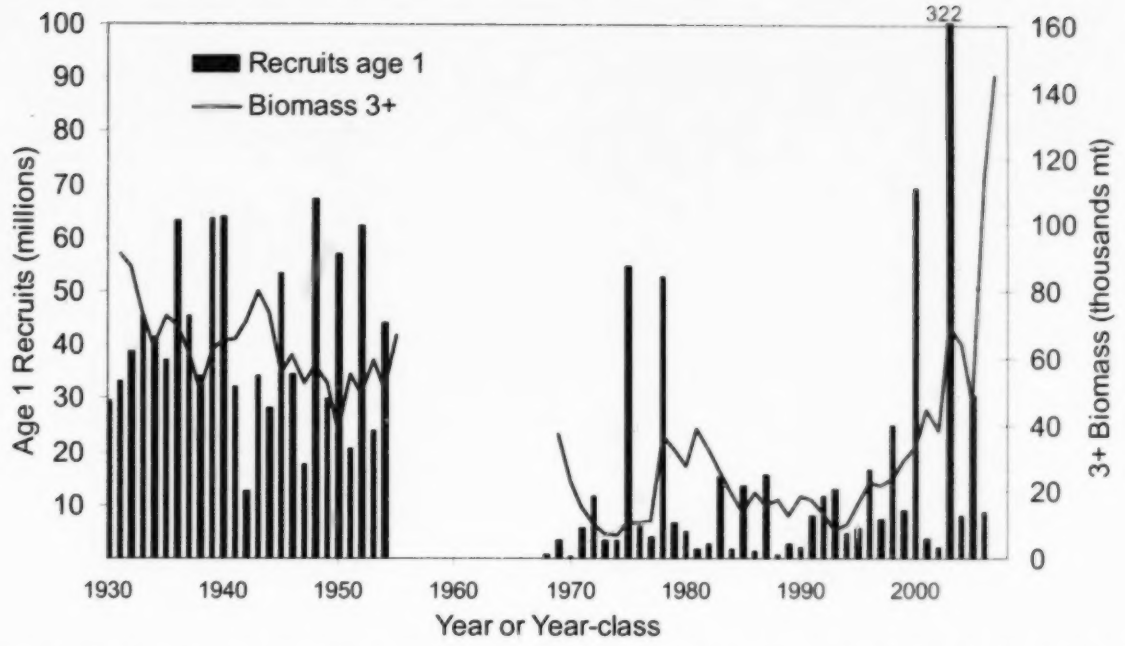

Figure 30. Beginning of year adult (3+) biomass and number of age 1 recruits for EGB haddock during 1931-1955 and 1969-2007.

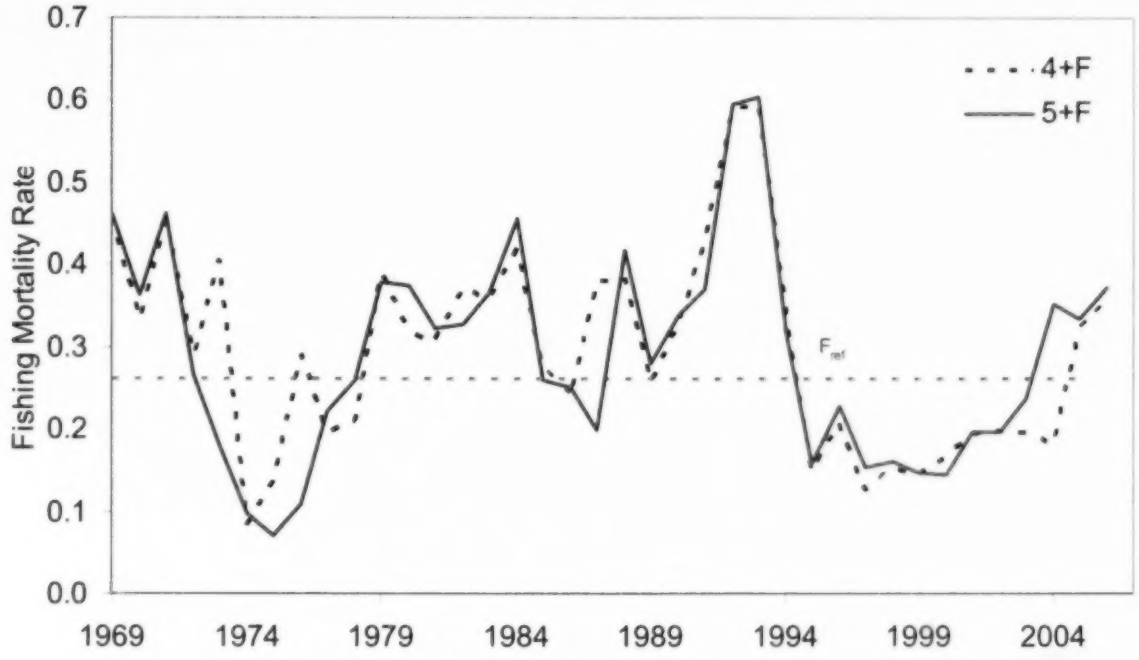

Figure 31. Fishing mortality rate (weighted by population) for EGB haddock ages 4+ and 5+ during 1969-2006 and the fishing mortality threshold reference established at F_{ref} = 0.26.

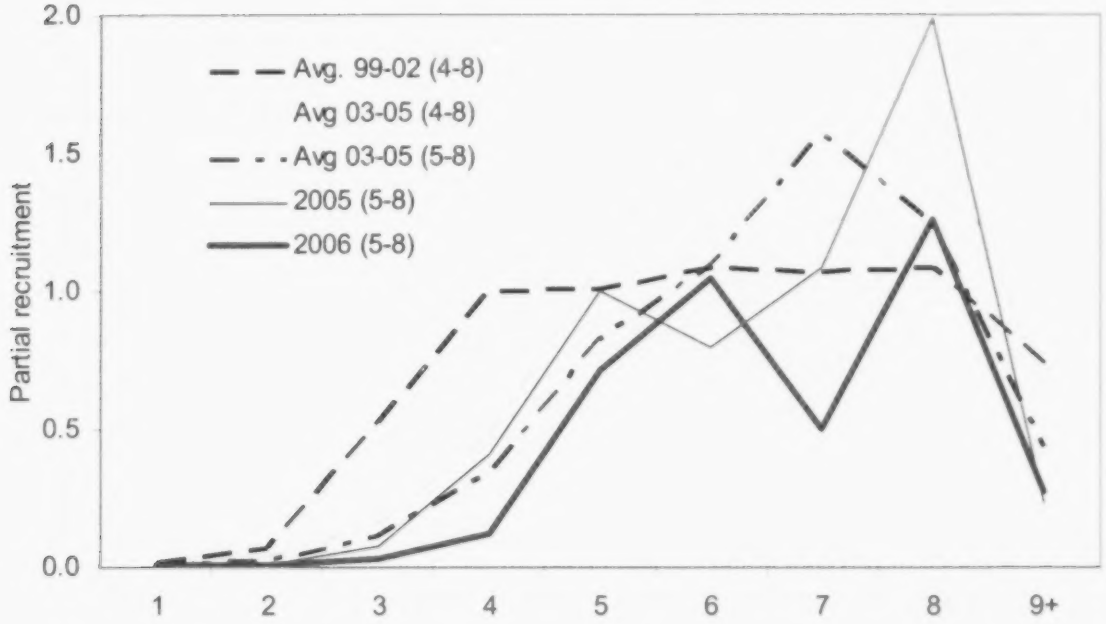

Figure 32. Average partial recruitment of EGB haddock for 3 time periods compared to the years 2005 and 2006. The partial recruitment is normalized to either ages 4-8 or 5-8, as indicated.

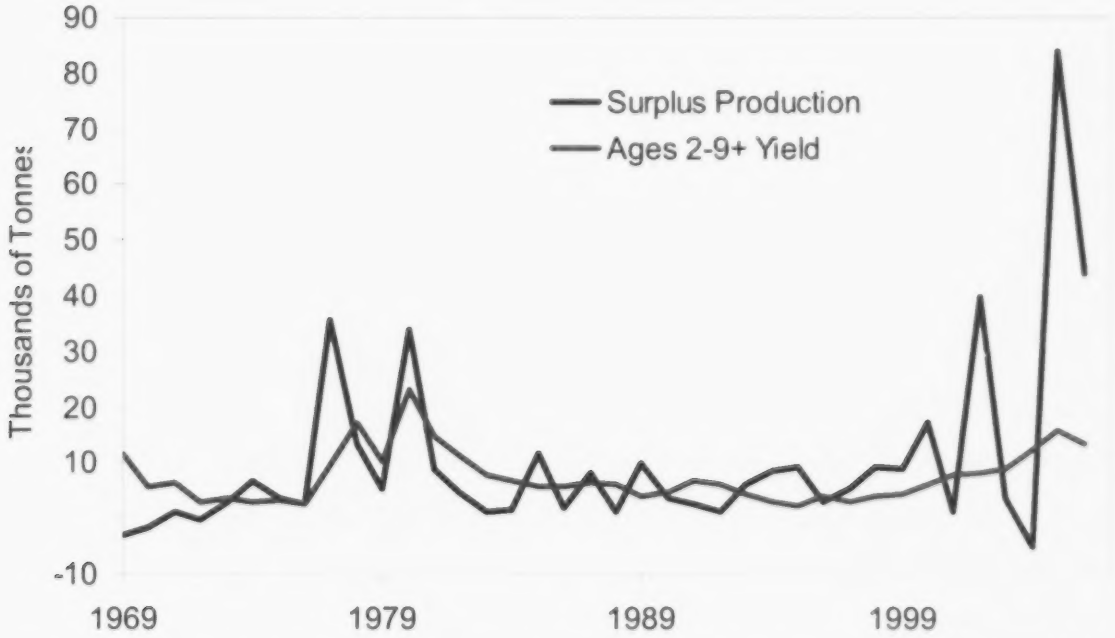

Figure 33. Surplus production of EGB haddock available to the commercial fishery compared to the harvested yield during 1969-2006.

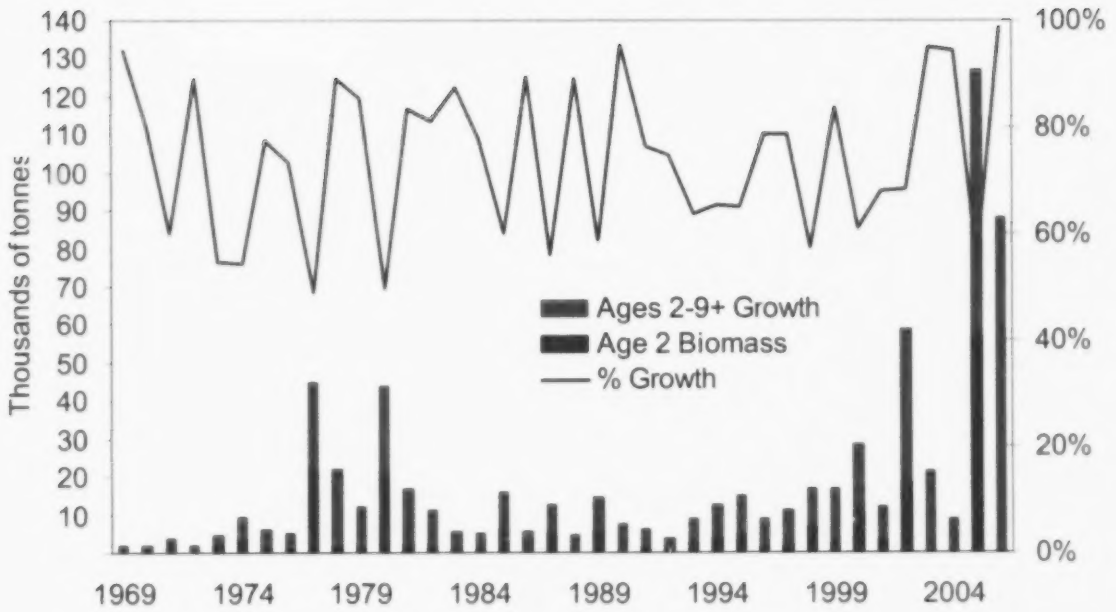

Figure 34. Amount of productivity attributible to growth (ages 2 to 9+) of EGB haddock and the amount contributed by recruitment (age 2) during 1969-2006.

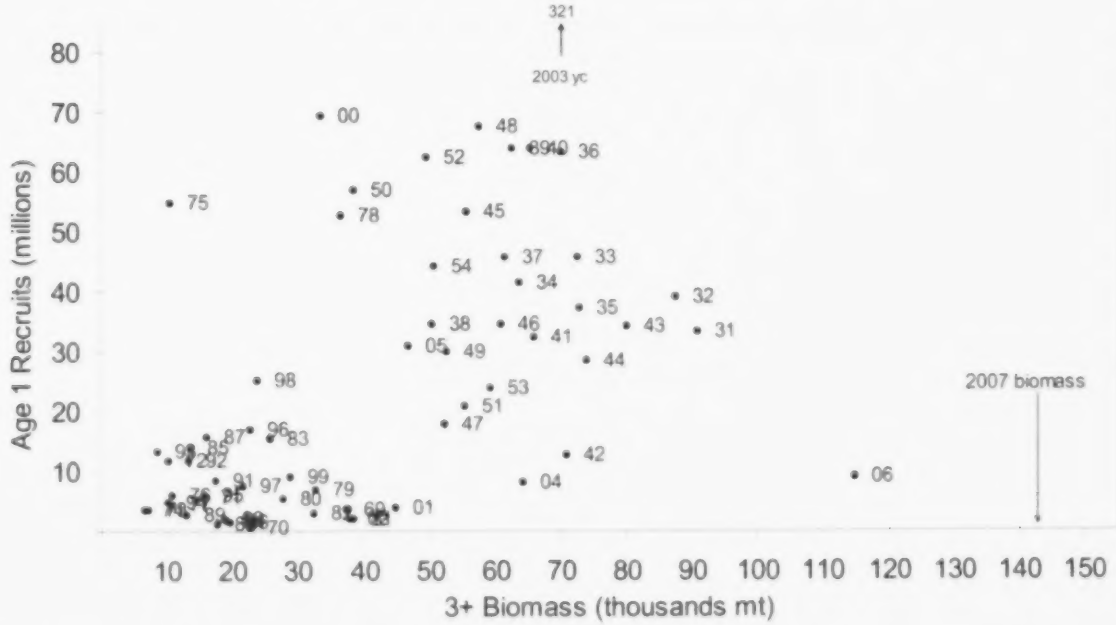

Figure 35. Relationship between EGB adult (ages 3+) haddock biomass and recruits at age during 1931-1955 and during 1969-2006.

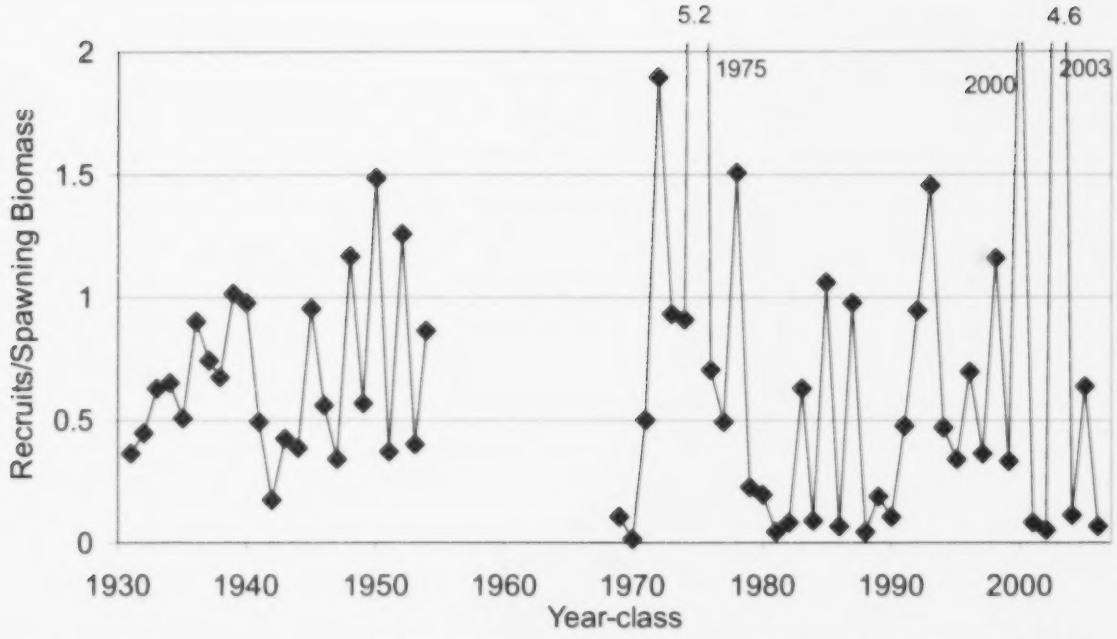

Figure 36. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for EGB haddock during 1931-1955 and during 1969-2006.

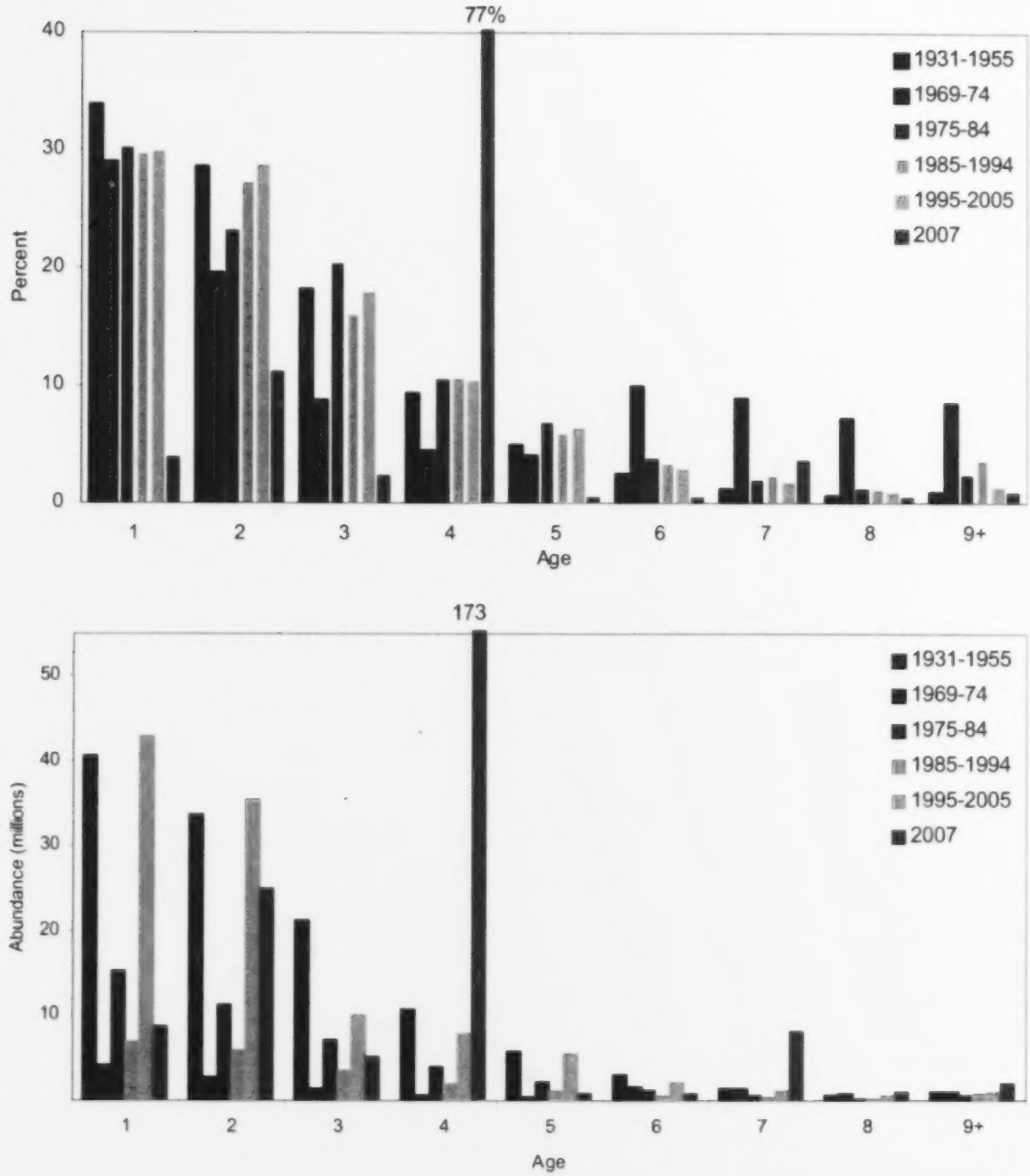

Figure 37. The age composition and absolute abundance at age of the EGB haddock population in 2007 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2005.

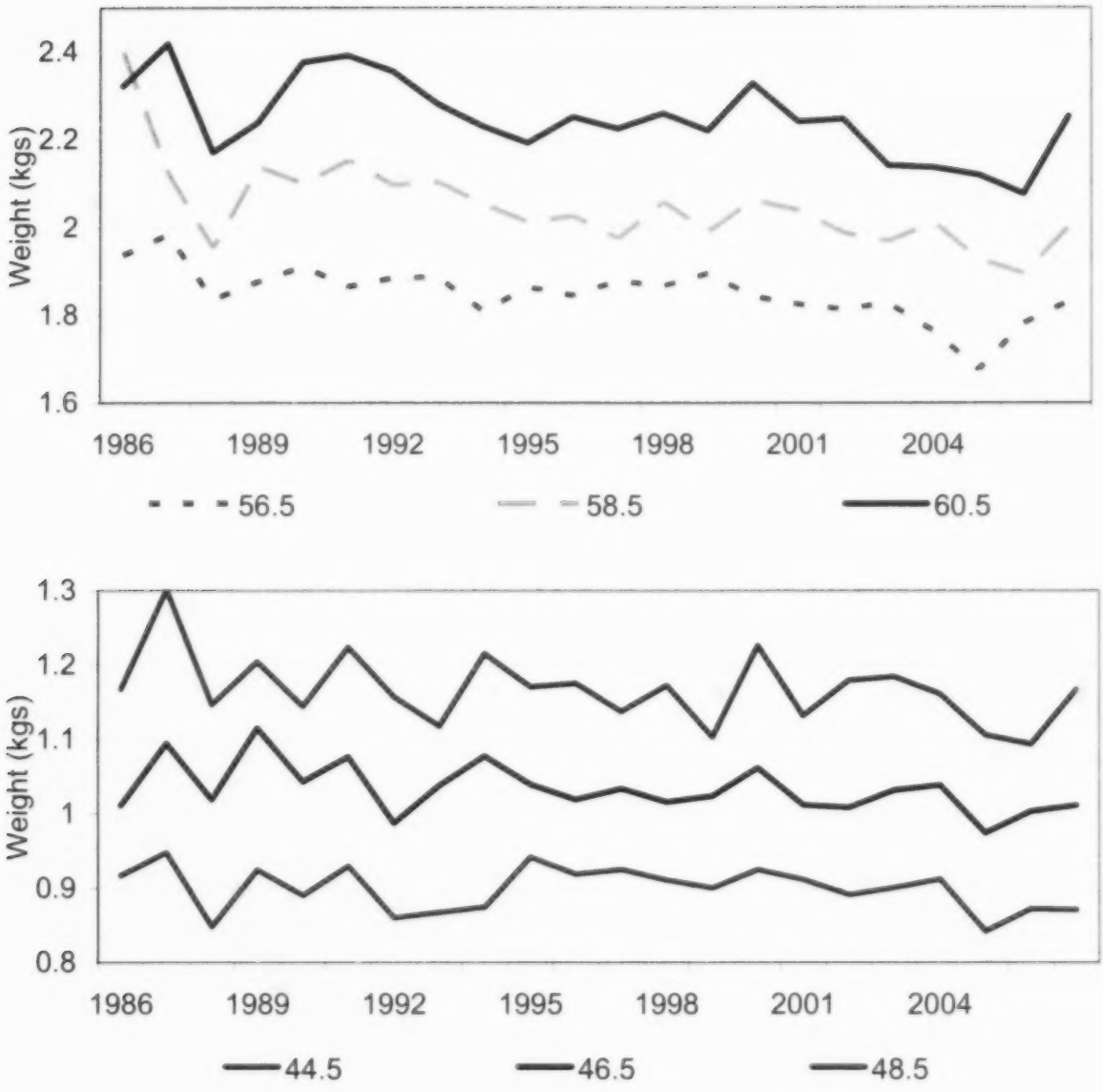

Figure 38. DFO survey weights at lengths for EGB haddock for six 2 cm length groupings during 1986-2007.

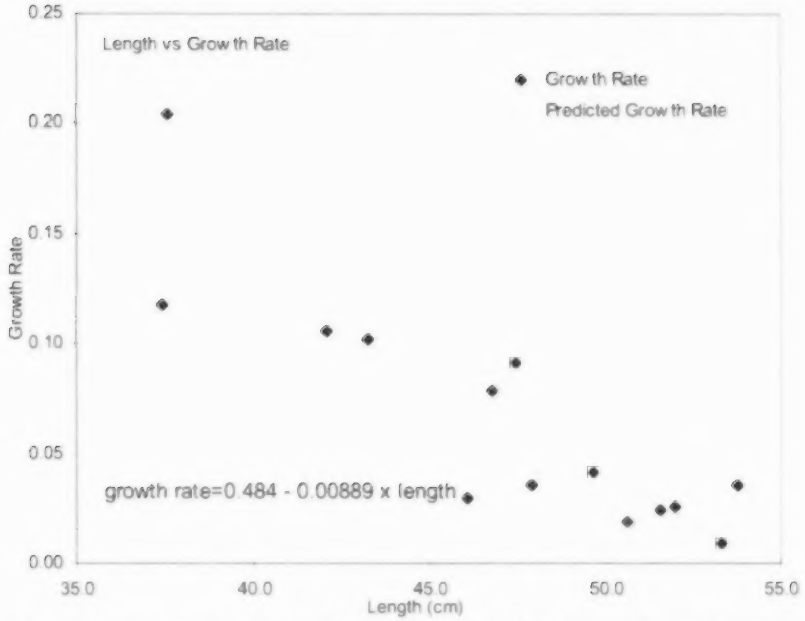

Figure 39. Relationship between length and growth rate derived for EGB haddock using observed growth increments from the 1998, 1999 and 2000 year classes.

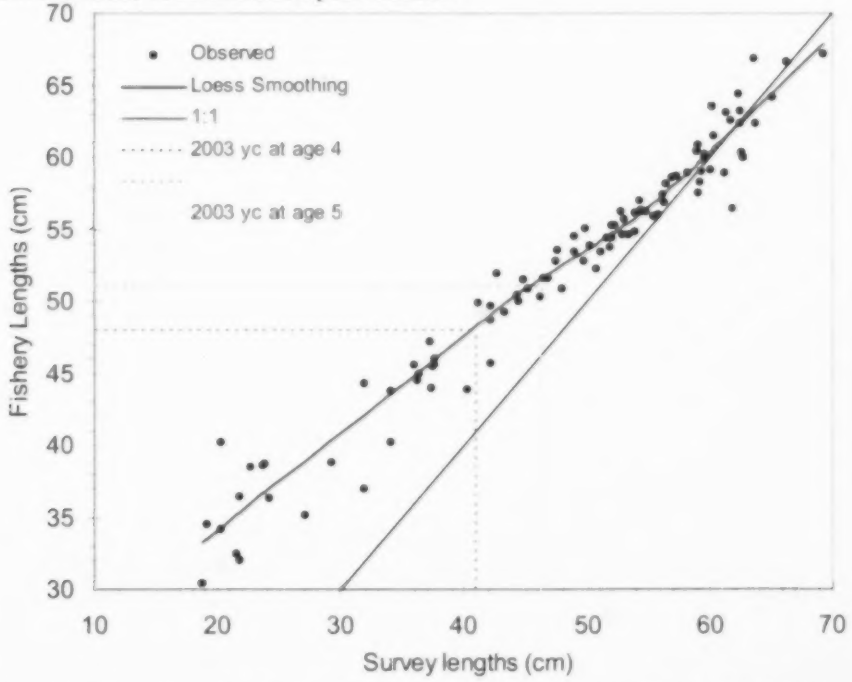

Figure 40. Relationship between EGB haddock beginning of year lengths (from DFO surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Clevand 1979). The lengths of the 2003 haddock year class at age 4 (41 cm) and age 5 (46.2 cm) with the corresponding fishery lengths are indicated. The 1:1 line is added for illustrative purposes.

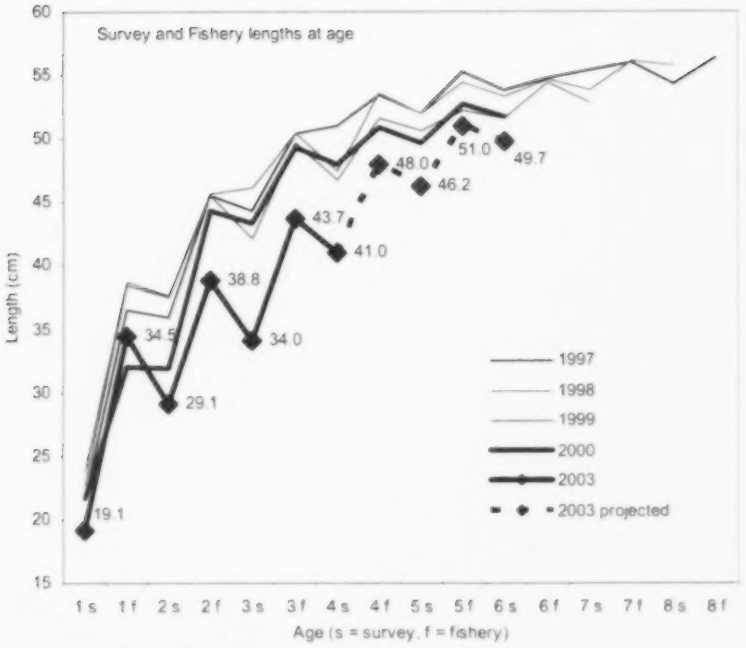

Figure 41. Average population lengths at age and average fishery lengths at age of the 1997 to 2000 and 2003 year classes of EGB haddock as observed from the DFO survey. Predicted lengths for the 2003 year class are indicated by ◆.

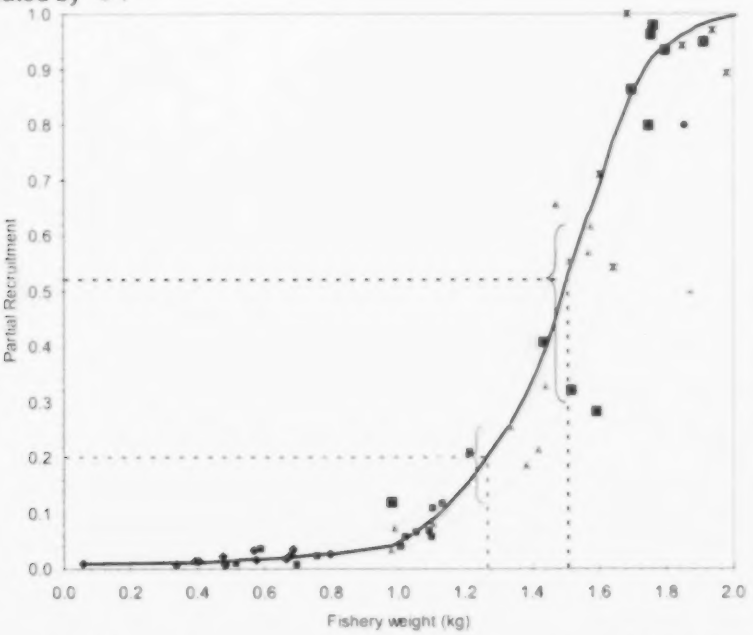

Figure 42. Fishery weight and partial recruitment relationship observed for EGB haddock in 2003 to 2005. A smoothed line was fitted to the data using a loess algorithm (Cleveland 1979). The 2003 year class predicted fishery weight at age 4 (1.263 kg) and 5 (1.507 kg) with the corresponding partial recruitment (0.2 and 0.52, respectively) are indicated by the dotted lines. The gray lines approximate the upper and lower range of partial recruitment values.

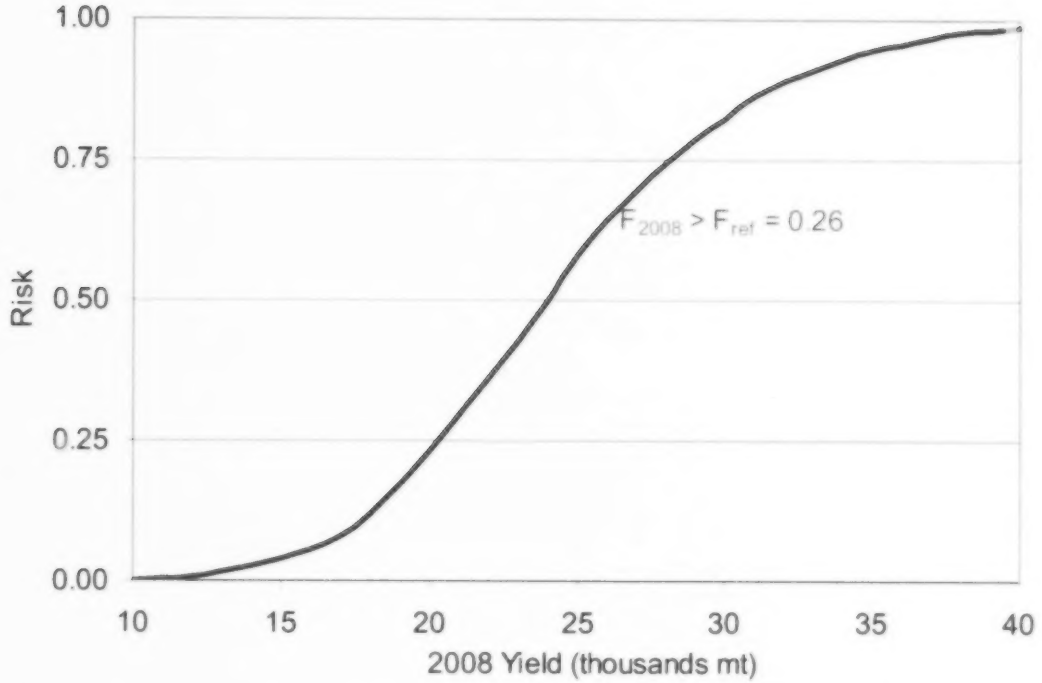

Figure 43. Risk of 2008 fishing mortality exceeding F_{ref} = 0.26 for EGB haddock for increasing catch quotas.